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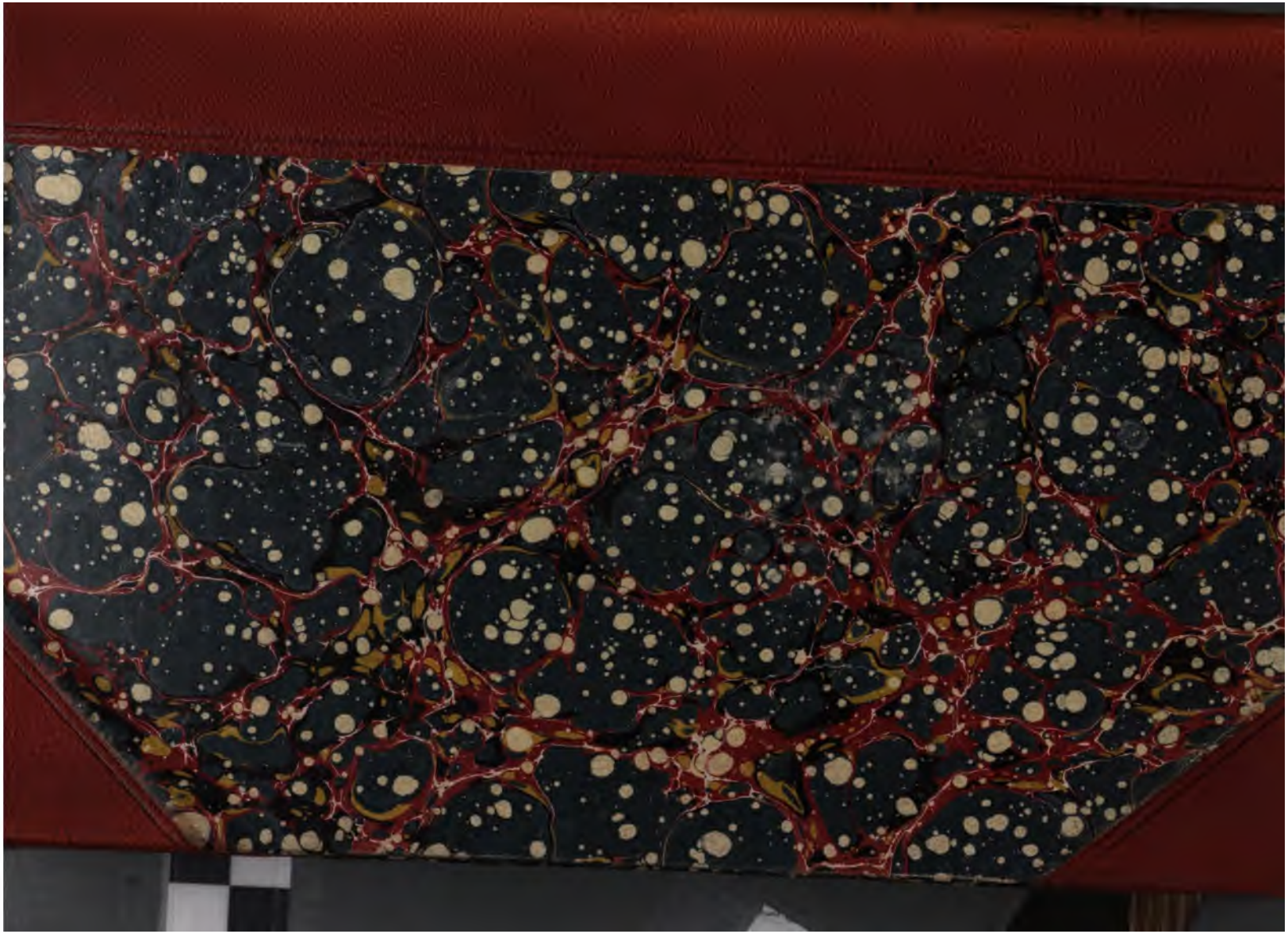

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TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL SOCIETY.

EDITED BY

THE HONORARY SECRETARIES.

VOLUME SIXTEENTH,

PARTS I.—XVIII., 1880-1-2.

MANCHESTER:

SOLD AT THE ROOMS OF THE SOCIETY,

36, GEORGE STREET, MANCHESTER.

1882.

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*** The writers of papers alone are responsible for the facts and opinions contained in their respective communications.

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MANCHESTER GEOLOGICAL SOCIETY.

Established 15th October, 1838.

OBJECTS.

The objects of the MANCHESTER GEOLOGICAL SOCIETY *are the collection and diffusion of Practical and Theoretical Knowledge respecting Geology and Mining. In furtherance of such objects, original Papers on Geology and Mining subjects—either written by the members of the Society, or communicated to the Society through a member, on behalf of the authors—shall be read and discussed at its meetings, and if judged to be of sufficient interest, shall be printed at the expense of the Society, in its Transactions.*

RULES.

I.—The Society consists of Ordinary, Life, Honorary, and Corresponding Members.

II.—Every candidate for admission into the Society as an ordinary member, must be proposed by two or more members, who must sign a certificate in recommendation of him, setting forth the name, description, and place of residence of the candidate.

III.—The certificate, when duly filled up, shall be read aloud at the next ordinary meeting of the Society; and the election of the candidate shall forthwith be decided by a majority of votes.

IV.—The Secretaries shall address to every person elected a member, a notification of such election, with a copy of the printed Rules and Bye-laws of the Society.

V.—No person elected a member shall be entitled to exercise any privilege as such, until he shall have paid his annual subscription, or the composition in lieu thereof.

VI.—The annual subscription to be paid by ordinary members shall be twenty shillings, due on each successive first day of October, and payable in advance for the current year, and shall be a debt due to and recoverable as such by the Treasurer for the time being.

VII.—Members joining the Society on or after the first day of April in any year, shall pay the sum of ten shillings as the subscription for the current year.

VIII.—An ordinary member may, at his election, or any future period, become a life member by compounding for future annual subscriptions, including that of the current year, by the payment of ten pounds. If he has already paid the subscription for the current year, or any part of it, such payment shall be allowed in part of his composition.

IX.—The payment by an ordinary or life member, of the subscription, or the composition in lieu thereof, shall imply the acquiesence of such member in the Rules and Regulations of the Society, and shall entitle him (so long as no subscriptions remain unpaid) to admission to the meetings of the Society, the use of the Library, and to one copy of each of the Transactions, and of any other publications the Society may print.

X.—Individuals distinguished for their Geological or Mining researches, for their liberality to the Society, or for their connexion with other Societies, may, on the recommendation of the Council, be elected honorary or corresponding members of this Society at any ordinary or general meeting. But such honorary or corresponding members shall have no vote in the affairs of the Society.

XI.—Any member may withdraw from the Society by signifying his wish to do so, by letter under his hand, to the Secretaries, at the apartments of the Society; provided always, that such member shall be liable for the subscription for the whole year wherein he signifies his wish to withdraw; and shall continue liable to future annual subscriptions until he have discharged all sums due from him to the Society, and returned all books and

other property, if any, in his custody, belonging to the Society; or shall have made full compensation for the same if lost or not forthcoming after two months' notice from the Secretaries.

XII.—As soon as any member has let his subscriptions fall two years in arrear, the Secretary shall notify the fact to him, and require him to pay what is due within one month. In case of non-compliance with such request, the Council may determine the membership of the defaulter.

XIII.—An annual meeting of the Society shall be held in the month of October, for the purpose of electing the officers for the current year, receiving the Annual Report of the Council, together with an Audited Statement of the Receipts and Expenditure of the last year, and transacting the general affairs of the Society. At this meeting any member may question the Council upon any matter contained in such report, and comment thereon, and on any other matters of which notice in writing had been previously given to the Council, relating to the affairs of the Society, as to him may appear proper.

XIV.—Ordinary meetings of the Society shall be held once, at least, in every month, from October to June, inclusive, at such time as the Council shall appoint. Each member shall have the power to introduce visitors to the meetings, on entering their names in a book to be kept for that purpose.

XV.—Ordinary meetings may be held in other localities than Manchester, according to the pleasure of the Society, to be determined at a previous meeting.

XVI.—Circulars announcing meetings of the Society, or of the Council, shall be sent, free of postage, to the respective members of those bodies, at least three days before such meeting.

XVII.—Special general meetings may be summoned by the Council, or by the Secretaries, on the requisition, in writing, of any six members of the Society, by notice delivered free, or sent by post, pre-paid, to all the members whose addresses are known, not less than one week, nor more than a fortnight, before any such meetings. Such notice shall state the time and place of

holding the meeting, and the specific purposes for which it is convened; and the business of such meeting shall be restricted to such purposes.

XVIII.—At the hour appointed for a meeting of the Society or Council, the chair shall be taken by the President, or the senior Vice-President present, and in their absence the meeting shall, previously to entering upon any other business, elect some member present to be Chairman.

XIX.—All questions discussed at any such meeting, except as otherwise provided, shall be decided by a majority of votes; and if upon any question the votes shall be equal, the Chairman of the meeting shall have a second vote as a casting vote.

XX.—No business shall be done at any such ordinary or special meeting unless when five members at least are present, except that any number of members who may be present, not being less than two, may adjourn the meeting to a future day, such adjourned meeting to be summoned in the same manner as the original meeting.

XXI.—A President, four Vice-Presidents, two Honorary Secretaries, and a Treasurer, shall be elected at each annual meeting; and the foregoing, together with twelve ordinary members, to be elected at the same time, shall form the Council of the Society, and shall have the management of its affairs, except as is otherwise provided by these Rules; and at the same meeting two Auditors shall be elected for the year ensuing. These elections shall be by ballot. In addition to the four Vice-Presidents annually elected, the Ex-Presidents shall be *ex post officio*, Vice-Presidents of the Society.

XXII.—Any member who has been for six months a member of the Society, and whose subscription is not in arrear, shall be eligible to be elected an officer or member of the Council.

XXIII.—In the event of any vacancy occurring during the year in the Officers or Council, the same shall be filled up by the Council.

XXIV.—The President shall not be eligible for that office for more than two years in succession; and the two Vice-Presidents, and the four members of the Council who shall have attended the meetings of Council the least number of times, shall be ineligible to the same office for the ensuing year.

XXV.—The Council shall have power to make Bye-laws and Regulations, in accordance with the general Rules of the Society, to appoint, suspend, or dismiss salaried agents, clerks, or servants; to purchase and collect books, maps, models, specimens, and other objects; to provide rooms for the meetings of the Society, and pay rent for the same; and to purchase furniture or other articles that they deem necessary for the use of the Society.

XXVI.—The Council shall meet once at least in every month, and upon such other occasions as they may deem expedient. Special meetings of the Council may be called by either of the Secretaries, or on the requisition of any three members of the Council, of which number the officer convening such meeting may be one; any three members of the Council present at a meeting being sufficient to constitute a quorum.

XXVII.—A minute of the proceedings of all meetings shall be entered by the Secretaries in a book to be kept for that purpose.

XXVIII.—The Council shall decide whether a paper shall be printed in the Transactions or not, and if they do not unanimously agree to print it, or reject it, they may refer it to one or more members of the Society, to report upon its merits, and, in exceptional cases, refer it to competent persons who are not members. After having received such reports, the Council shall decide without delay whether or not the paper is to be printed. The author of a paper shall be at liberty to reserve his right of property therein, and shall have a right to withdraw it from publication, by giving timely notice to the Council.

XXIX.—All moneys, the Library, and all chattels of the Society, shall be held by the President and Treasurer for the time being, as legal owners thereof, but in trust for the Society, and under the direction of the Council, and all investments shall be

made in the names of such members, not being less than two, as the Society may from time to time appoint.

XXX.—All the funds and moneys of the Society shall be applied by or under the direction of the Council, in paying the debts and demands for the time being owing by the Society, and carrying out the purposes thereof as defined in the preceding Rules; and no dividend, gift, division, or bonus in money shall at any time, or under any circumstances, be made unto or between the members of the Society, or any of them.

XXXI.—No additional rule, nor any alteration or repeal of any existing or future rule or rules of the Society shall be made, unless with the consent of three-fourths in number of such of the ordinary and life members as may be present at any annual or special meeting; and the proposed change must be announced by circular to the members whose addresses are known, at least three weeks before such meeting.

XXXII.—The Society shall not be dissolved, nor shall the Library or other property be disposed of, unless with the consent, in writing, of three-fourths of such of the ordinary and life members as may be present at each of two successive special general meetings, duly convened by public advertisement in the Manchester daily newspapers, and by notice sent by post at least one calendar month before each meeting, to all members, whose addresses are known; such meetings to be held at an interval of not less than two, nor more than four, calendar months.

By order of the Council,

JOHN EDWARD FORBES, F.G.S., } HONORARY
JOSEPH SAMUEL MARTIN, F.G.S., } SECRETARIES.

BYE-LAWS

FOR

REGULATION OF THE LIBRARY.

I.—No Book, Map, or document shall be taken from the Library without the same being first entered in a Register, in such manner as the Council shall from time to time direct.

II.—The time allowed for retaining a Book, &c., shall not exceed one calendar month.

III.—No Member shall be allowed to renew a Volume, Map, &c., in case any other Member shall have entered his name as being desirous of taking out the same on its return. Such Volume, Map, &c., shall, on its return from the person holding the same, be entered as taken out by the Member so applying, and shall not be taken away by any Member, save him in whose name it is entered, till the expiration of the period for which the Member in whose name it is entered would have been entitled to hold the same. At which period the said Book, &c., (in case the same shall not have been taken out by the party in whose name it is entered on the Register,) shall be returned in the Register as returned.

IV.—The time allowed for holding shall, in every case, be computed from the date of the entry in the Register.

V.—Every Member shall return the Books, Maps, and documents belonging to the Society in as good a condition as when they were delivered into his possession, and shall be answerable for the same till their return from him, to the Society, is correctly entered in the Register.

[redacted]

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART I. VOL. XVI. SESSION 1880-81.

ANNUAL MEETING.

The ANNUAL MEETING of the Members of the Society was held on Tuesday, the 26th day of October, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOSEPH DICKINSON, Esq., F.G.S., Vice-President, in the Chair.

Mr. H. H. Bolton, jun., Newchurch, near Manchester; Mr. Thomas Bromley, 37, Bank Top, Radcliffe; Mr. W. W. B. Hulton, of Hulton Park, near Bolton; Mr. Matthew Kennedy, Colliery Manager, Brinsop Hall Colliery, Wigan, were elected ordinary members of the Society.

The Report of the Council and the Treasurer's Balance Sheet were read by Mr. J. S. Martin, Honorary Secretary.

REPORT OF THE COUNCIL FOR 1879-80.

In presenting the following report to the Forty-second Annual Meeting, the Council is gratified to be able to say that the Society continues in a sound and satisfactory position. The number of members has steadily increased during the Session, and, judging by the attendance at the

meetings, which have been larger than for many years back, the work has been appreciated.

It is hoped that this state of affairs will continue, and that members will make increased efforts to contribute and obtain papers of interest to be read and discussed, as it is only by the assistance and co-operation of the members that the success of the Society can be maintained.

The number of new members elected has been as follows:—1 honorary, 1 life, and 25 ordinary members; while the loss has been 9,—one (Mr. J. Diggle) by death, and 8 by resignation, &c.; leaving a total number enrolled at the present time of 188, viz.:—18 honorary, 10 life, and 160 ordinary members.

Papers, both scientific and practical, have been read and discussed at the several meetings of the Society, and the parts of the Transactions appertaining thereto have been distributed among the members.

The monetary position of the Society is also satisfactory. The amount (£18 4s. 5d.) owing to the Hon. Treasurer at the end of last year, as well as all expenses up to the present date, have been paid off from the current income, and a balance (£19 15s. 11d.) carried forward to the credit of the Society, leaving the previous investments unaltered.

The sale of Transactions has been considerably less than during the previous year, which was exceptionally large.

The arrangement made with the Literary and Philosophical Society, enabling members to consult the works in the library at its domicile, has been made use of to a small extent, and it is expected that as the arrangement becomes better known and understood by the members, it will be found a great convenience by many for the purpose of reference, &c.

The number of books taken out of the library has also increased slightly, and the Council takes this opportunity of

again bringing under the notice of members that where it may not be convenient for them to call at the Society's rooms, the books will be forwarded, at their risk and expense, on application being made to the Hon. Secretaries.

In the beginning of August a two days' excursion was made to the Nottingham and South Yorkshire Coal Fields, in conjunction with the members of the South Staffordshire and East Worcestershire Institute of Mining Engineers. About 30 members of this Society took part in it, and met the other party accompanied by their President (Mr. W. J. Hayward), and then proceeded together to view several of the works in the districts named.

The excursion was most successful, having proved both instructive and enjoyable, and the thanks of the Society are due to Mr. Hayward, the President, and the other members of the South Staffordshire and East Worcestershire Institute, for the cordial and courteous manner in which they received the request of this Society to be allowed to join them. Thanks are also due to Mr. Alexander Smith, their Secretary, upon whom the arrangements of the excursion devolved, as also to the several owners, agents, and officials of the works visited for their kindness and courtesy in rendering every facility to the members for seeing all that was of interest.

It is hoped that arrangements will be made during the ensuing Session for similar excursions to local and more distant works and places of interest, as field work in geology and mining is essential for progress in these subjects, and gives opportunity of gaining information for which book-learning can only be considered preparatory.

THE FOLLOWING IS A LIST OF PAPERS AND COMMUNICATIONS WHICH HAVE BEEN BROUGHT BEFORE THE ORDINARY MEETINGS DURING THE SESSION.

1879.

November. Burn's Patent Brake.

Crofton, Rev. A., M.A., "Notes on the Geology of the Shap District."

Grimshaw, W. J., F.G.S., "On Incrustation and Deposits in Steam Boilers."

December. Pennington, Rooke, F.G.S., "Upon the Arrangement of a Geological Museum."

Aitken, John, "On the Discovery of an Ancient Iron Mine in Cliviger, and some further Remarks on the Remains of Old Bloomeries in the Neighbourhood of Todmorden."

1880.

January. Topping, Walter, "On the Method adopted in Sinking through Quicksand at the Bamfurlong Collieries, Wigan."

Mello, Rev. J. M., M.A., F.G.S., "Notes on the More Recent Discoveries in the Creswell Caves."

February. Perrin, J. Beswick, F.L.S., &c., and John Plant, F.G.S., "On Concretionary Nodules of Limestone and Foliated Mouldings in the Permian Marls, near Leigh."

Grimshaw, W. J., F.G.S., and Herbert Phillips, "On the Long Wall System of Working Coal." Part I.

March. Forbes, Prof. G. "Description of Damposcope, or Fire Damp Indicator."

Grimshaw, W. J., F.G.S., and Herbert Phillips, "On the Long Wall System of Working Coal." Part II.

April.	Aitken, John. "Discoveries of Boulders near Manchester."
	Aitken, John. "Discovery of Fossil Trees near Oldham."
	Grimshaw, W. J., F.G.S., and Herbert Phillips. "On the Long Wall System of Working Coal." Part III.
	Hollingworth, G. H., F.G.S. "A Description of Messrs. Booth and Sugden's Detaching Hook."
	Watts, William, F.G.S., "On the Geological Strata and Mode of Procedure in Driving a Tunnel at Saddleworth."
May.	"Creswell Discoveries." Discussion.
	Kendall, J. D., C.E., F.G.S., "On the Formation of Rock Basins."
June.	Smith, Dr. Angus, "On the Spark Tube or Inflammable Gas Indicator."
	DeRance, C. E., F.G.S., "Further Notes of Triassic Borings near Warrington."

Dr. MANCHESTER GEOLOGICAL SOCIETY.—BALANCE SHEET. *Cr.*

Abstract of Receipts.	£	s.	d.
1879-80.—To Bank Interest	0	3	10
,, Birkenhead Dividends	23	9	6
,, Sale of Transactions	1	17	11
,, Subscriptions and Arrears..	153	0	0
	£178	11	3
1880. To Balance brought down, due to Society .	19	15	11

Abstract of Payments.	£	s.	d.
1879-80.—By Balance due to Treasurer....	18	4	5
,, Library	4	19	7
,, Reporters.....	9	9	0
,, Transactions, &c.....	57	4	0
,, Circulars, Stationery, &c. ..	8	1	9
,, Postages	18	1	1
,, Collector's Commission	7	13	0
,, Rent, &c.....	30	0	0
,, Attendance	4	10	0
,, Insurance	0	12	6
,, Balance	19	15	11
	£178	11	3

The Investments consists of £600 Four per cent. Guaranteed Stock of the Birkenhead Railway in the names of Henry More Ormerod and Andrew Knowles.

The Society further possesses a valuable Library, and there are also £29 of arrears of Subscriptions.

Audited and found correct, 19th October 18th,

HENRY M. ORMEROD, Treasurer.
11th October, 1880.

EDWARD PILKINGTON.
CLEGG LIVESEY.

On the motion of Mr. AITKEN, seconded by Mr. PLANT, the Report and Balance Sheet were unanimously adopted, and ordered to be printed.

The following noblemen and gentlemen were proposed, seconded, and declared duly elected as Officers and Members of the Council for the ensuing year:—

President:

SIR UGHTRED J. KAY-SHUTTLEWORTH, BART.

Vice-Presidents:

RIGHT HON. THE EARL OF BRADFORD.
RIGHT HON. THE EARL OF ELLESMERE.
GEORGE GILROY, M.Inst.C.E.
G. S. FEREDAY SMITH, M.A., F.G.S.

Ex-Officio Vice-Presidents:

SIR PHILIP DE MALPAS GREY-EGERTON, BART., M.P., F.R.S.

JAMES HEYWOOD, F.R.S.	JOHN AITKEN.
G. W. ORMEROD, F.G.S.	JOHN KNOWLES, M.Inst.C.E.
E. W. BINNEY, F.R.S.	THOMAS KNOWLES, M.P.
JOSEPH DICKINSON, F.G.S.	W BOYD DAWKINS, F.R.S.
ANDREW KNOWLES.	R. CLIFFORD SMITH, F.G.S.
G. C. GREENWELL, F.G.S.	JOHN E. FORBES, F.G.S.

LORD LINDSAY, F.R.S.

Treasurer:

HENRY MERE ORMEROD, F.G.S.

Secretaries:

JOSEPH S. MARTIN, F.G.S.	G. C. GREENWELL, JUNR.

Other Members of the Council:

JAMES ATHERTON.	J. BESWICK PERRIN, F.K. Col. Lond., M.R.C.S.E., F.L.S.
W. J. GRIMSHAW, F.G.S.	J. F. SEDDON.
CHARLES HARDWICK.	W. SMETHURST, F.G.S.
JOHN L. HEDLEY.	PETER SPENCE, F.C.S.
CHARLES G. JACKSON.	GEORGE WILD.
ROOKE PENNINGTON, F.G.S.	

H. A. WOODWARD.

Auditors:

EDWARD PILKINGTON.	CLEGG LIVESEY.

NEW ORDINARY MEMBERS.

Armandale, John Thomas
Barton, Richard, Jun.
Boon, John Thomas
Burns, Thomas.
Carter, James.
Crompton, William.
Dixon, Charles William
Drinnan, Richard.
Duncan, Dr.
Fairclough, William.
Fairley, Joseph Smith.
Grimke, Thomas Drayton.
Hargreaves, John.
Heyes, James.
Jackson, William.
Johnson, Isaiah.
Mailing, William.
Pace, Thomas.
Phillips, Herbert.
Pilkington, Charles.
Sixsmith, John.
Speakman, John.
Stirrup, Mark, F.G.S.
Teale, William K.
Unsworth, Richard.

NEW LIFE MEMBER.

Christopher James Schofield.

NEW HONORARY MEMBER.

Theophile Guibal.

MEMBER DECEASED.

James Diggle.

MEMBERS RESIGNED.

Alcock, Thomas, M.D.
Crofton, Rev. A., M.A.
Evans, T. Fanning.
Johnson, J. H., F.G.S.
Nesbitt, George.
Statter, William H.
Waters, A. W., F.G.S.
Wild, Samuel.

PAST PRESIDENTS OF THE SOCIETY.

Year of Election.	
1838-9-40	Egerton, The Rt. Hon. Francis, M.P.
1841-2-3	Heywood, James, F.R.S., F.G.S.
1843-4-5	Egerton, Sir Philip de Malpas Grey-, Bart., M.P.
1845-6-7	Mosley, Sir Oswald, Bart.
1847-8-9	Thicknesse, Ralph, M.P., Wigan.
1849-50-1	Heywood, James, M.P., F.R.S.
1851-2-3	Black, James, M.D., F.G.S.
1853-4-5	Ormerod, G. W., M.A., F.G.S.
1855-6-7	Egerton, Sir Philip de Malpas Grey-, Bart., F.G.S.
1857-8-9	Binney, E. W., F.R.S., F.G.S.
1859-60-1	Kay-Shuttleworth, Sir J. P., Bart., M.P.
1861-2-3	Dickinson, Joseph, F.G.S.
1863-4-5	Knowles, Andrew.
1865-6-7	Binney, E. W., F.R.S., F.G.S.
1867-8-9	Greenwell, G. C., F.G.S.
1869-70-1	Aitken, John, F.G.S.
1871-2-3	Knowles, John, M.Inst.C.E.
1873-4	Knowles, Thomas, M.P.
1874-5	Dawkins, Professor W. Boyd, F.R.S., F.G.S.
1875-6	Smith, R. Clifford, F.G.S.
1876-7	Dawkins, Professor W. Boyd, F.R.S., F.G.S.
1877-8	Dickinson, Joseph, F.G.S.
1878-9	Forbes, John E., F.G.S.
1879-80	Lindsay, Lord, F.R.S.

LIST OF MEMBERS.

NOVEMBER, 1880.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of Election.	
1877	Adamson, Daniel, F.G.S., The Towers, Didsbury.
1874	*Agassiz, Alexander*, Cambridge, Massachussetts, U.S.A.
1863	Aitken, John, Sandfield, Urmston. *Past-President.*
1879	Arrandale, John Thomas, Bradford Colliery, Manchester.
1877	Arthur, David, Baxenden Collieries, near Accrington.
1865	Ashworth Edward, Stagg Hills, Waterfoot, near Manchester.
1878	Ashworth, James, 56, Upper Duke Street, Southport.
1878	Ashworth, Thomas, 32, St. Ann's Street, Manchester.
1877	Atherton James, 16, Acresfield, Bolton. *Member of Council.*
1878	Atkinson, Samuel C., Stand Lane Colliery, Radcliffe.
1878	Atkinson, W. N., H.M. Inspector of Mines, Shincliffe Hall, Durham.
1866	Bamford, J. B., Mining Engineer, Rochdale.
1876	Barnes, R. J., Birley Collieries, near Sheffield.
1875	Barrett, W. S., New Hall, 41, Old Hall Street, Liverpool.
1880	Barton, Richard, jun., Westleigh Lodge, Leigh, near Manchester.
1879	Baxter, Henry, Tyldesley Colliery, Tyldesley.
1858	Bazley, Sir Thomas, Bart., Eyford Park, Stow-on-the-Wold, Gloucesteshire.
1877	Beswick, James, Little Hulton, near Bolton.
1862	Beswicke, William, Bank Side House, Manchester Road, Rochdale.
1838	Binney, E. W., F.R.S., F.G.S., 55, Peter Street, Manchester. *Past-President.*
1867	Bolton, H. H., Newchurch, near Manchester.
1880	Bolton, H. H., junr., Newchurch, near Manchester.

Year of Election.	
1880	Boot, John Thomas, The Orchards, Hucknall, near Mansfield.
1878	Bradford, The Right Hon. Earl of, Weston Park, near Shifnal. *Vice-President.*
1878	Brocklehurst, Thomas, Dean, Bolton.
1877	*Broeck, Ernest Vanden*, 124, Rue Terre Neuve, Brussells.
1880	Bromley, Thomas, 57, Bank Top, Radcliffe.
1877	*Brongniart, Charles*, Museum d'Histoire Naturelle, 57, Rue Cuvier, Paris.
1861	Brooks, Thomas, Crawshaw Hall, Rawtenstall.
1859	Bryham, William, Ince Hall, Wigan.
1862	*Buccleuch, His Grace the Duke of, Whitehall Gardens, London, S.W.
1879	Burns, Thomas, Plank Lane Colliery, Westleigh, Leigh, near Manchester.
1875	Burrows, Abraham, Atherton Collieries, near Manchester.
1878	Burrows, John S., Atherton Collieries, near Manchester.
1874	Byrom, W. A., F.G.S., 31, King Street, Wigan.
1879	Carter, James, 1, Granville Terrace, Blackburn.
1878	Clayton, Abel, 11, Chapel Walks, Manchester.
1878	Cooke, Charles, Moston Colliery, Failsworth.
1859	*Coulthart, John Ross, F.R.S.Lit., F.S.A.Scot., Croft House, Ashton-under-Lyne.
1878	Cowburn, Henry, West Leigh, near Manchester.
1880	Crompton William, Ince, near Wigan.
1862	Cross, John, 78, Cross Street, Manchester.
1860	Crowther, Samuel, Bradford Estate Offices, Bolton.
1876	Cunliffe, P. G., The Elms, Handforth, near Manchester.
1860	Darbishire, R. D., B.A., F.G.S., 26, George Street, Manchester.
1869	Dawkins, Professor W. Boyd, M.A., F.R.S., The Owens College, Manchester. *Past-President.*

Year of Election.	
1877	*De Rance, C. E.*, F.G.S., Geological Survey, Jermyn Street, London, S.W.
1862	*Derby, The Right Hon. the Earl of, Knowsley.
1877	Derry, Jos, Sneyd Colliery, Burslem.
1856	Dickinson, Joseph, F.G.S., H.M. Inspector of Mines, South Bank, Pendleton. *Past-President.*
1879	Dixon, Charles William, 19, King Street, Wigan.
1879	Drinnan, Richard, Outwood Colliery, near Manchester.
1880	Duncan, Dr., Tyldesley.
1877	Edmondson, Thomas, Cliviger Collieries, near Burnley.
1852	Egerton, The Hon. Algernon, Worsley Hall, near Manchester.
1838	*Egerton, Sir Philip de Malpas Grey, Bart., M.P., F.R.S., Oulton Park, Tarporley *Past-President.*
1878	Ellesmere, The Rt. Hon. Earl of, Worsley. *Vice-President.*
1838	*Embleton, T. W.*, The Ceders, Methley, Leeds.
1838	*Enniskellen, Earl of*, F.R.S., Florence Court, Fermanagh.
1865	Evans, Walter, Longsight, Oldham.
1880	Fairclough, William, Leigh, near Manchester.
1880	Fairley, Joseph Smith, 136, Huskisson Street, Liverpool.
1863	Farrar, James, 12, Market Street, Bury.
1873	Fletcher, Herbert, The Hollins, Bolton.
1875	Fletcher, Ralph, jun., Atherton Collieries, near Manchester.
1868	Fletcher, Thomas, Haulgh, Bolton.
1857	Forbes, John Edward, F.G.S., 46, Hyde Road, Manchester. *Past-President.*
1873	Garforth, W. E., Colliery Offices, Normanton.
1874	*Geikie, Archibald*, LL.D., F.R.S., Geological Survey Office, Edinburgh.
1858	Gerard, Lord, of Bryn, Garswood, near Newton-le-Willows.
1856	Gilroy, George, M.Inst.C.E., Hindley Hall, Wigan. *Vice-President.*

Year of Election.	
1878	Greener, W. J., Pemberton Colliery, Wigan.
1863	Greenwell, G. C., F.G.S., 8, Prior Terrace, Tynemouth. *Past-President.*
1874	Greenwell, G. C., junr., Poynton, near Stockport. *Hon. Secretary.*
1879	Greenwood, John, junr., Ashton Moss Colliery, Audenshaw, Manchester.
1879	Gregson, Edward, 11, Chapel Street, Preston.
1880	Grimke, Theodore Drayton, Whitledgehurst, Ashton-in-Wakerfield.
1864	Grimshaw, W. J., F.G.S., Stand Lane Colliery, Whitefield, near Manchester. *Member of Council.*
1877	Grundy, H. T., Radcliffe.
1877	Grundy, Joseph, Radcliffe.
1879	*Guibal, Theophile,* École des Mines, Mons, Belgium.
1866	Hall, John, Balderstone, Walmersley.
1864	Hall, Robert, Hope Foundry, Bury.
1877	Handsley, Robert, Burnley Colliery Offices, Burnley.
1861	Harbottle, W. H., Orrell Colliery, near Wigan.
1864	Hardwick, C., 72, Talbot Street, Moss Side, Manchester, *Member of Council.*
1880	Hargreaves, John, Winkhill, near Leek, Staffordshire.
1875	*Hawkins, B. W.,* F.G.S., Century Club, East 15th Street, New York.
1874	*Hawkshaw, Sir John,* Knight, F.R.S., 33, Great George Street, Westminster, S.W.
1877	*Hayden, F. V.,* State Geologist, Washington, U.S.A.
1878	Hedley, John L., H.M. Inspector of Mines, Flookersbrook, Chester. *Member of Council.*
1875	Hetherington, Joseph, 22, Booth Street, Manchester.
1874	Hewlett, W. H., Wigan Coal and Iron Co., Wigan.
1880	Heys, James, Westleigh, Leigh, near Manchester.
1838	*Heywood, James, F.R.S., F.G.S., 26, Kensington Palace Gardens, London, W. *Past-President.*

Year of Election.	
1862	Heywood, Oliver, Claremont, Pendleton.
1876	Higson, John, F.G.S., 18, Booth Street, Manchester.
1878	Holden, Charles H., Mawdesley Street, Bolton.
1877	Holding, William, Crossall Colliery, near Nottingham.
1878	Hollingworth, George H., F.G.S., Hollinwood, Manchester.
1878	Howell, John, Astley, near Manchester.
1874	*Hull, Professor Edward*, M.A., F.R.S., 5, Raglan Road, Dublin.
1880	Hulton, W. W. B., Hulton Park, near Bolton.
1878	Jackson, Charles G., Chamber Colliery Offices, Hollinwood, Manchester. *Member of Council.*
1875	Jackson, J., 5, Wood Street, Bolton.
1877	Jackson, Lewis, Rocher Colliery, Ashton-under-Lyne.
1880	Jackson, William, Bower Colliery, Hollinwood, Manchester.
1877	Jobling, John, Barcroft Hall, Cliviger, Burnley.
1879	Johnson, Isaiah, Unity Brook Colliery, Kearsley.
1844	*Joule, J. P., LL.D., F.R.S., 12, Wardle Road, Sale.
1880	Kennedy, Matthew, Brinsop Hall Collieries, Wigan.
1879	*Kinahan, G. H.*, M.R.I.A., Ovoca, Ireland.
1856	Knowles, Andrew, High Bank, Pendlebury. *Past-President.*
1859	Knowles, John, Westwood, Pendlebury. *Past-President.*
1877	Knowles, Lees, Westwood, Pendlebury.
1858	Knowles, Thomas, M.P., Darnhall Hall, Winsford, Cheshire. *Past-President.*
1858	Lancaster, John, F.G.S., Bilton Grange, Rugby.
1879	Lindsay, Lord, F.R.S., M.P., 47, Upper Brook Street, London. *Ex-President.*
1862	Livesey, Clegg, Woodley, Stockport. *Hon. Auditor.*
1877	Livesey, Thomas, Bradford Colliery, Manchester.
1878	Longbotham, Jonathan, Norley Colliery, Wigan.
1877	Lord, James, Hill House, Rochdale.
1879	Lupton, Arnold, F.G.S., Crossgates, near Leeds.
1861	Lynde, J. G., F.G.S., Gore Street, Greenheys, Manchester.

Year of Election.	
1878	Maiden, Samuel, Bridgewater Villas, Stockport.
1873	Martin, Joseph S., F.G.S., H. M. Inspector of Mines, Park Villas, Prestwich. *Hon. Secretary.*
1879	Melling, William, Plank Lane Colliery, Westleigh, Leigh, near Manchester.
1876	Moore, Alfred, C.E., 5 Clarence Street, Manchester.
1838	*Morton Charles* The Grange, Southport.
1874	*Morton, G. H.*, F.G.S., 122, London Road, Liverpool.
1878	Nall, Simon, Newbold, Rochdale.
1878	Nelson, William, Leigh, near Manchester.
1864	Nuttall, Thomas, Colliery Surveyor, Bury.
1874	*Ormerod, G. W.*, M A., F.G.S., Woodway, Teignmouth.
1838	Ormerod, H. M., F.G.S., 5, Clarence Street, Manchester. *Hon. Treasurer.*
1874	*Owen, Professor Richard,* D.C.L., F.R.S., &c., South Kensington Natural History Museum, London, W.C.
1862	Park, James, Fern Hill, Bury.
1880	Parr, Thomas, Westleigh, Leigh, near Manchester.
1876	Peace, George, Monton Grove, Eccles.
1877	Peace, Maskell W., F.G.S., Wigan.
1876	Penman, J. Hugh, 2, Clarence Buildings, Booth Street, Manchester.
1877	Pennington, Rooke, F.G.S., 20, Mawdsley Street, Bolton.
1878	Perrin, J. Beswick, F.K., Col. Lond., M.R.C.S.E., F.L.S., Leigh, near Manchester. *Member of Council.*
1879	Phillips, Herbert, Digby Collieries, near Nottingham.
1861	Pickup, Peter, F.G.S., Towneley Colliery, Burnley.
1877	Pickup, Peter Wright, Dunkenhalgh Collieries, Church, near Accrington.
1873	Pilkington, Alfred, Clifton Collieries, near Manchester.
1879	Pilkington, Charles, Ashton and Edge Green Colleries, St. Helens.

Year of Election.	
1873	Pilkington, Edward, Clifton Collieries, near Manchester. *Hon. Auditor.*
1877	Place, W. H., Hoddleston Colleries, Darwen.
1851	Plant, John, F.G.S., Royal Museum, Peel Park, Salford.
1867	Radcliffe, James, Fitz-William Main Hemsworth Colliery, Pontefract.
1874	*Ramsay, Professor A. C.*, LL.D., F.R.S., &c., 15, Cromwell Crescent, South Kensington, S.W.
1860	Ridyard, John, Walkden, Bolton.
1877	Robins, George, Ashton, near Newton-le-Willows.
1880	*Schofield, Christopher James, Whalley Villa, Whalley Range, Manchester.
1873	Seddon, J. F., Great Harwood Collieries, Accrington. *Member of Council.*
1866	Selby, Atherton, Mining Engineer, Leigh.
1878	Settle, Miles, Snow Hill, Darcy Lever, near Bolton.
1877	Shuttleworth, Sir Ughtred J. Kay-, Bart., Gawthorpe Hall, Burnley. *President.*
1879	Sixsmith, John, Snydale Hall Colliery, Chequerbent, Bolton.
1864	Smethurst, William, F.G.S., Garswood Hall Colliery, Ashton, near Wigan. *Member of Council.*
1873	*Smith, R. Clifford, F.G.S., Parkfield, Swinton, near Manchester. *Past-President.*
1838	Smith, G. F., M.A., F.G.S., Grovehurst, Tunbridge Wells. *Vice-President.*
1866	Sopwith, Arthur, F.G.S., Cannock Chase Collieries, Walsall.
1880	Speakman, John, The Walmsleys, Leigh, near Manchester.
1862	Spence, Peter, F.C.S., Erlington House, Seymour Grove, Old Trafford. *Member of Council.*
1859	Statter, Thomas, Stand Hall, Bury.
1878	Stephens, James Henry, Leigh, near Manchester.
1880	Stirrup, Mark, F.G.S., 21, Heywood Street, Moss Side, near Manchester.

Year of Election.	
1880	Teale, William E., Fern Bank, Worsley.
1877	Tomlinson, Thomas, 3, Richmond Terrace, Whitehall, London, S.W.
1873	Tonge, James, Woodbine House, Westhoughton, near Bolton.
1876	Topping, Walter, Ashton, near Wigan.
1858	*Trafford, Sir Humphrey de, Bart., Trafford Park, Manchester.
1876	Unsworth, John, Scot Lane Collieries, near Wigan.
1879	Unsworth, Richard, Mesne Lea Colliery, Worsley.
1877	Waddington, Henry, Burnley Collieries, Burnley.
1877	Waddington, John, Burnley Collieries, Burnley.
1862	Wadham, Edward, Millwood, Dalton-in-Furness.
1862	*Walsh, Eli, Over Darwen.
1879	Walshaw, John, Astley and Tyldesley Collieries, Tyldesley.
1879	Warburton, William, High Lane, near Stockport.
1878	Wells, Samuel B., 130, Bradford Street, Haulgh, Bolton.
1877	West, T. E., 65, Werneth Hall Road, Oldham.
1877	Wheeler, Harold George, Cockeymoor Colliery, Radcliffe.
1865	Whipp, Thomas, Hawthorn Villas, Prestwich.
1867	Wild, George, Bardsley Colliery, Ashton-under-Lyne. *Member of Council.*
1877	Wild, Joseph, 25, Long Causeway, Farnworth, near Bolton.
1876	Winstanley, Robert, 32, St. Ann's Street, Manchester.
1876	Woodward, H. A., Clifton, near Manchester. *Member of Council.*
1877	Yates, T. M., Anderton Hall Colliery, Blackrod, Chorley.

PRESENTATIONS TO THE LIBRARY, 1879-80.

Birley, Hugh, M.P.—Reports of the Inspectors of Mines. 1879.

Cambridge University.—Reports of the Museums and Lecture Rooms Syndicate. For 1878-9.

Chester Society of Natural Science.—Proceedings. Nos. 1 and 2. *From the Society.*

Cornwall and Devon.—Reports and Proceedings of the Miners' Association. 1879.

Cornwall.—Royal Institution.—Journal. No. 22. 1880.

Dublin.—Royal Dublin Society.—

The Journal. No. 45. Vol. VII.
Publication ceases with this number.
,, Transactions. Vol. I. Parts 1-12.
,, ,, ,, II. ,, 1-2.
,, Proceedings. Vol. I. Parts 1-3.
,, ,, ,, II. ,, 1-6.
From the Society.

Edinburgh Geological Society.—Transactions. Vol. III. Part 3. *From the Society.*

Edinburgh Royal Society.—Proceedings. Vols. I., II., III., IV., V., VI., VIII., IX., and Part 1, Vol. X. (*Parts 4, 8, and 13, Vol. —, and Vol. VII. being out of print, are wanting.*) *From the Society.*

Glasgow Geological Society.—Transactions. Vol. VI. Part 1. *From the Society.*

Glasgow Natural History Society.—Proceedings. Vol. IV. Part 1. 1878-9. *From the Society.*

Hull, E., F.G.S.—*Pamphlet.*—On the "Dingle Beds."

Hertfordshire Natural History Society and Field Club.—Transactions. Vol. I. Part 1. *Form the Society.*

Institution of Mechanical Engineers.—Proceedings. No. 5, 1879, and Nos. 1 and 2, 1880. *From the Council.*

Iron and Steel Institute.—Journal. Nos. 1 and 2, 1879, and No. 1, 1880. *From the Council.*

Kinahan, G. H.—*Pamphlet*—Address to the Royal Geological Society of Ireland.

Leeds Geological Association.—*Pamphlet*—Opening Address of 5th Session.

Leeds.—Yorkshire Geological and Polytechnic Society. Vol. VII. Part 2. New Series. *From the Society.*

Leicester Literary and Philosophical Society.—Transactions. Part 6. 1855 to 1860, and for the 45th Session, 1879-80, and Report for 1880. *From the Council.*

London Geological Society.—Quarterly Journal. Nos. 140-3, and Abstracts of Proceedings for the Session 1879-80. *From the Society.*

London Geologists' Association.—Proceedings. Nos. 4-7. Vol. VI. 1879-80. *From the Council.*

Manchester Scientific Students' Association.—Report and Proceedings for 1878 and 1879.

Midland Institute of Engineers.—Transactions. Parts 48-50. Vol. VII. *From the Council.*

Mining Institute of Scotland.—Transactions. Vol. II. Parts 1-5. 1880. From the Council. *Formerly West of Scotland Mining Institute.*

North of England Institute of Engineers.—Transactions. Parts 1-4. Vol. XIX. *From the Council.*

Oxford University.—Catalogue of Books added to the Radcliffe Library in 1879. Per Dr. H. M. Ackland, Librarian.

Percy, C. M. *Pamphlet.*—On Winding and Overwinding, describing Safety Detaching Hooks, &c.

South Wales Institute of Engineers.—Proceedings. Vol. XI., Parts 7 and 8, and Vol. XII., Parts 1 and 2. 1879-80. *From the Institute.*

The Owens College Calendar. Session 1880-1. *From the Council.*

Watford Natural History Society and Hertfordshire Field Club.—Proceedings. Vol. II. Parts 2-8. *From the Council.*

West of Scotland Mining Institute *(Henceforth, Mining Inst. of Scotland).*—Transactions. Vol. I. Parts 7-11. 1879-80. *From the Council.*

Wigan Free Library.—Catalogue of Works on Mining, Metallurgy, and Manufactures. 1880. *From the Committee.*

Annual Reports, from the Committees.

Chester Society of Natural History. 1879-80.
Devon and Exeter Free Library. 1879-80.
Dundee Free Library. 1878-9.
Geologists' Association for 1878-9.
Leicester Town Museum. 1880.
Liverpool Free Library. 1878-9.
Salford Museum, Libraries, and Parks. 1877-8 and 1878-9.

America.

Agassiz, Alexander.—Museum of Comparative Zoölogy, Cambridge, U.S.A.

Annual Report of the Curator. 1878-9.
Bulletin. Vol. V. Nos. 15 and 16. Vol. VI. Nos. 1-7. Vol. VII. (Vol. I. Geological Series) No. 1.

Gilbert, G. K. U.S. Geological and Geographical Survey of the Rocky Mountain Region.—Report on the Geology of the Henry Mountains.

Hayden. F. V.—"The Great West." Its Attractions and Resources, &c. Article by the Donor.

U.S. Geological and Geographical Survey of the Territories of Idaho and Wyoming. 1877.
U.S. Geological Survey of the Territories. Vol. XII.

Sheafer, P. W.—Diagram of the Progress of the Anthracite Coal Trade of Pennsylvania.

Pamphlet.—On the Anthracite Coal Fields of Pennsylvania and their Exhaustion.

Smithsonian Institution, U.S.A.—Annual Report for 1878. *From the Council.*

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FOREIGN.

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BOOKS PURCHASED 1879-80.

Coal Mine Gases and Ventilation. Thomas. 8vo. 1878.

Geological Magazine. Nos. 187-196. 1880.

Geological Record. 1877.

Metalliferous Minerals and Mining. Davies. 8vo. 1880.

Palœontographical Society. *Monograph.* Vol. XXXIV.

Societies with whom the Society Exchanges its Transactions, and Institutions and Journals to whom a Copy is sent Free.

I.—England.

London	British Museum.
	Geological Society.
	Geological Survey.
	Geologists' Association.
	Institute of Mechanical Engineers, Victoria Street, S.W.
	Iron and Steel Institute.
	Royal Institution.
	Royal Society.
Manchester	Field Naturalists' Society.
	Free Library.
	Literary and Philosophical Society.
	Owens College.
	Scientific Students' Association.
	Salford Royal Museum and Library.
Barnsley	Midland Institute of Mining Engineers.
Birmingham	Free Library and Museum.
Bristol	Naturalists' Society.
Cambridge	Geological Museum, University.
	University Library.
Chester	Society of Natural Science.
Chesterfield	Institute of Mining Engineers, &c. (in bound vols.)
Cornwall	Royal Geological Society, Penzance.
	Royal Institution, Truro.
Dudley	South Staffordshire and East Worcestershire Institute of Mining Engineers.
Exeter	Albert Memorial Museum.
Hertford	Natural History Society and Field Club.
Leeds	Geological and Polytechnic Society.
	Philosophical and Literary Society.
Leicester	Literary and Philosophical Society.
Liverpool	Free Library and Museum.
	Geological Society.

Newcastle-on-Tyne..Institute of Mining and Mechanical Engineers.
Oxford .....Bodleian Library.
Radcliffe Library.
South Shields ....Public Free Library.
Stoke-on-Trent....North Staffordshire Institute of Mining and Mechanical Engineers.
Swansea .....South Wales Institute of Mining and Mechanical Engineers.
Truro .....Miners' Association of Cornwall and Devon.
Warwick .....Natural History Society.
Wigan .....Free Library.
Mining School.

II.—Scotland.

Dundee.....Free Library and Museum.
Edinburgh .....Advocates Library.
Geological Society.
Royal Society.
Royal Physical Society.
Glasgow .....Geological Society.
Natural History Society.
Hamilton .....Mining Institute of Scotland.

III.—Ireland.

Dublin .....Royal Dublin Society.
Royal Geological Society of Ireland.
Trinity College Library.
Belfast.....Natural History Society.

IV.—Australia.

Melbourne.....Public Library of Victoria.
Sydney.....Free Public Library.
Royal Society of N. S. Wales.
Newcastle.....John Mackenzie, F.G.S.

V.—Canada and United States.

Montreal .....Geological Survey of Canada (A. R. C. Selwyn, F.G.S., Director).
M'Gill College (Principle, J. W. Dawson, F.G.S.)

Toronto . . . . . Canadian Institute.
Albany, U.S. . . . Verplanck Colvin.
Boston, U.S. . . . Free Library.
Columbus, U.S. . . Ohio. Geographical Survey of Dr. J. S. Newberry, F.G.S.
Easton, U.S. . . . . American Institute of Mining Engineers.
Indianapolis, U.S. E. T. Cox, State Geologist.
Newhaven, U.S. . . Professor O. C. Marsh, F.G.S.
Washington, U.S. Smithsonian Institution.

VI.—Foreign Societies.

Berlin . . . . . Geological Society of Germany.
Calcutta . . . . . Geological Survey of India.
Christiania . . . . . Royal University of Norway.
Halle, A.S. . . . . . Verein für Erdkunde.
Lausanne (Suisse) Société Vaudoise des Sciences Naturelles.
Lille . . . . . Société Géologique du Nord.
Pisa . . . . . Società di Scienci Naturali.
Rio de Janeiro . . . . Museu Nacional.
St. Petersburg . . . . Academy Imperial.
Turin . . . . . Academie Royale.

VII.—Scientific Journals, &c.

Geological Magazine, Geological Record, Mining Journal, Colliery Guardian, Iron and Coal Trades Review.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART II. VOL. XVI. SESSION 1880-81.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 30th day of November, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

Sir UGHTRED J. KAY-SHUTTLEWORTH, Bart., President, in the Chair.

Mr. William Speakman Brown, of Pear Tree House, Tyldesley; Mr. Arthur Woodbyne Parish, Engineer, Clowes House, Higher Broughton, Manchester; and Mr. William Watts, F.G.S., Piethorne, near Rochdale, were elected ordinary members of the Society.

The following additions to the Library, received since the last Meeting, were laid on the table.

Presented by the Societies and Authors where not otherwise stated.

Leeds Philosophical and Literary Society: Annual Report, 1879-80. London Geological Society: Quarterly Journal, No. 144; List of Members, 1880. Manchester Literary and Philosophical Society: Memoirs, Vol. VI., 3rd Series (Vol. XXVI., Old); Transactions, Vols. XVI.-XIX. Mining Institute of Scotland: Transactions, Vol. II., Part 6. North of England Institute of Mining and Mechanical Engineers: Transactions, Vol. XIX.,

Part 5. Académie Impériale des Sciences de St. Pétersburg: Memoirs, Vol. XXVII., Nos. 2-4: Bulletin, Tome XXV., Nos. 5 and 6. Società Toscana di Scienze Naturali: Memorie, Vol. IV., fasc. 2°. Verein für Erdkunde zu Halle a. S.: Mittheilungen, 1880. Creswell Caves, by T. Heath. U.S. Geological and Geographical Survey of the Territories (History of North American Pinnipedes, &c.) Miscellaneous Publications, No. 12; *from Dr. F. V. Hayden, Director of the U.S. Geological Survey.* Geological Survey of Victoria: Vols. II.-VI.; *from Thomas Cockburn, Esq., Secretary of Mines, &c., Victoria.*

The PRESIDENT, upon taking his seat, said: In taking the chair here for the first time, I have to thank you for the honour which you have done me in electing me President of this Society. I feel that I shall have the support of the Officers, of the Vice-Presidents, and Past-Presidents of the Society, in carrying out the duties; otherwise, I should have hesitated, as indeed I did hesitate, very much in accepting the post. I am very sorry I am so much engaged that, for the present at least, I cannot offer you an address on Geology or mining, which, I understand, is expected; but on that subject I hope you will be indulgent with me.

ON THE DISCOVERY OF ROCK SALT AT PREESAL, LANCASHIRE.

By JOSEPH DICKINSON, F.G.S.

It will not be surprising to those who are conversant with the geology of the neighbourhood of Fleetwood that rock salt has recently been sunk to at Preesal. In an official report made by me on the salt districts, relative to landslips,

and printed by order of the House of Commons, 6th May, 1873, and in information given by me to this Society, I have attributed the ancient Brine Spring at Barton, near Downholland, mentioned in Baines's History of Lancashire, as well as the subsidences of land by which the Guttern and White Otter Meres, near Birkdale, Southport; and the subsidences with encroachments of the sea at South Shore, Blackpool; and further north to near Ulverston, to the solution of Rock Salt. Mention has also been made by other members to this Society of Rock Salt having been met with in a borehole put down some years ago at Fleetwood. The new exploration at Preesal, however, having been successful, gives the subject an additional interest, and I am happy in being able, with the consent of Mr. R. Howson, of Middlesbrough-on-Tees, by whom and his friends the exploration has been made, and from my own knowledge, to give the following particulars:—

The site of the exploration is about half a mile south-west of the village of Preesal, and about a mile and a half in a direct line south-east of Fleetwood. A shaft eight feet in diameter, bricked throughout, has been sunk to a depth of about 309 feet, and from the bottom of it a borehole has been put down, making the total depth proved 525 feet. The strata passed through were ordinary saliferous marls and marlstones, some containing gypsum, which continued to a depth of 258ft. 6in. At that depth Rock Salt was met with, which, with divisions or partings, continued for 266ft. 6in., to the bottom of the borehole, without being got through.

This thickness of Rock Salt is similar to that met with in the salt districts of Cheshire and County Antrim, where Rock Salt is being worked, and to what has been proved by boring at Middlesbrough, and Port Clarence, near the mouth of the Tees, and also at Stoke Prior, Worcestershire.

The following is a section of the Strata sunk and bored through at Preesal:—

	ft.	in.		Total depth ft.	Total depth in.
Soil	1	0	..	....	
Sand, with gravel	1	0	..	2	0
Soft blue clay, with sand and water	44	5	..	46	5
Running sand and water	2	0	..	48	5
Hard strong clay	24	0	..	72	5
Blue and yellow stone	5	8	..	78	1
Soft red shale, with blue and white partings	53	3	..	131	4
Blue shale, with gypsum	25	0	..	156	4
Red shale, with gypsum	44	4	..	200	8
Gray shale, with gypsum	5	0	..	205	8
Brown shale, and gypsum	35	0	..	240	8
Very soft gray shale, with gypsum, tastes salt	17	10	..	258	6
Rock salt, and red shale	19	6	..	278	0
Rock salt, with partings	6	0	..	284	0
Rock salt, with red shale	18	0	..	302	0
Hard rock salt (bottom of shaft in this)	19	0	..	321	0
Hard rock salt	14	9	..	335	9
Shale, and rock salt	1	4	..	337	1
Rock salt	5	6	..	342	7
Gray shale	2	0	..	344	7
Red rock salt	2	0	..	346	7
Rock salt, with gray shale partings	17	0	..	363	7
Gray and red shale, with rock salt	5	0	..	368	7
Hard rock salt	12	11	..	381	6
Red shale, and rock salt	13	10	..	395	4
Hard rock salt	6	1	..	401	5
Red shale, and rock salt	4	3	..	405	8
Rock salt	9	9	..	415	5
Rock salt, with gray shale partings	....		..	525	0

TEMPERATURE OF STRATA AND SEAMS OF COAL TAKEN IN THE NEW SINKINGS OF THE CLIFTON AND KERSLEY COAL COMPANY AT NEW-TOWN COLLIERIES, CLIFTON,

From August 1st, 1878, to November, 1880.

By Herbert Alfred Woodward, Civil and Mining Engineer.

We had got down to a depth of over 200 yards before the experiments commenced, having previously only taken a few observations.

The holes were drilled as soon as possible in the newly exposed face of the rock or coal, some vertically in the bottom of the shaft, and others horizontally in the sides; the shafts did not make much water, so that most of the holes were dry or nearly so, which was favourable to our observations. I have in each case in my tabulated statement kept a record of the condition of the drill hole.

When the drill indicated that we had got to a seam of coal, we bored through one or two feet of the overlying measures into the seam and inserted the thermometer so as not to give it a chance of cooling down, which I found took place rapidly when the coal was exposed.

The shafts were sunk at an average rate of one yard per day, so that the measures had little time for cooling.

The height of the top of the shaft is 286·8 feet above the Ordnance datum or mean level of the sea, and the depth below the sea level of the bottom of the shaft, as at present sunk, is 1428·2 feet, or a total depth from the surface of 1715 feet.

Depth in feet from Surface.	Difference of Depths.	Height of Barometer.	Temperature. Degrees F. On Surface.	Of Working Place.	Of Rocks.	Of Coal Seams.	Depth of Drill Hole.	Time Thermometer was in, in Minutes.	State of Drill Hole.	
608	..	29·07	60	65	62	..	36	30	..	Metal above 4ft. Mine.
612	4	..	..	..	..	62½	30	30	Wet.	Four Feet Mine.
612	..	..	..	..	..	64	30	30	Dry.	,, ,, ,,
648	36	29·45	57	61	63	..	30	30	,,	Rock.
653	5	..	..	..	..	64	32	30	,,	Little Mine Coal.
710	57	..	..	60½	64½	..	36	30	,,	Sandstone Rock.
735	25	..	63	71	65	..	32	30	,,	Metal above Rams Mine.
740	5	..	..	..	..	66	36	32	,,	Rams Mine Coal.
807	67	29·80	..	..	66½	..	36	35	,,	White Sandstone Rock, 40 yds. thick, with Lead Ore Veins; the heat of this Rock was constant, not varying more than ½ deg. in the whole thickness.
907	100	..	..	..	66½	..	32	30	,,	
1058	151	..	..	..	67	..	..	..		Blue Metal.
1062	4	..	57	66	..	69	27	30	,,	White Mine Coal.
1101	39	29·72	..	..	68	..	28	36	,,	Faulty Measures.
1120	19	..	..	..	70	..	32	35	,,	,, ,,
1135	15	..	54	68½	..	71½	30	32	,,	Black Mine Coal.
1200	65	29·20	..	..	72	..	..	..	,,	Blue Metal.
1294	94	29·00	57	71	..	77	27	27	,,	Doe Mine Coal.
1297	3	..	..	70	75	..	30	30	,,	Metal below Doe Mine.
1333	36	..	..	70½	..	77½	30	32	Damp.	Five Quarters Mine Coal.
1384	51	..	58	..	76½	..	36	35	,,	Rock and Metal, mixed.
1433	49	..	..	..	..	78½	32	35	,,	Hill Hole Mine.
1500	67	..	51	71	77¾	..	36	30	,,	Rock and Metal.
1602	102	29·50	52	..	78	..	36	20	,,	Sandstone Rock.
1614	12	..	..	..	78	..	36	30	,,	,, ,,
1621	7	..	..	..	79+	..	36	20	Dry.	,, ,,
1629	8	..	..	..	..	80	32	30	,,	Trencherbone Mine, No. 3 Shaft
1642	13	29·50	51	73	..	80½	34	30	,,	,, ,, No. 2 ,,
1642	..	..	..	..	..	80	34	27	,,	,, ,, No. 2 Level
1653	11	..	..	..	81	..	36	35	,,	Metal above Dye House Coal.
1674	21	29·65	43	74	..	82+	33	30	,,	Dye House Coal.
1680	6	30·20	39	72	80+	..	34	30		Metal below ,,
1681	1	..	..	..	..	80	..	..		Thermometer left in drill hole 15 hours, and the temperature fell to 78 deg. F. When taken out it was slightly wet from condensation.
1686	5	30·25	36	70	78	..	35	30	,,	In metal below Dye House Mine
1715	29	30·35	49	72	78+	..	34	60	,,	In rock in bottom of Shaft; the thermometer left in 12 hours, and the temperature fell slightly.

I have given in most cases the height of the barometer on the surface, the temperature on the surface, the temperature of the working place, and of the rocks and metals, and the seams of coal.

The temperature of the working place would be affected by the air blown down by the Schielie fan, and also by the air from the compressors, which drove the Burleigh rock drills; as, if the place became too hot, the sinkers used to let the compressed air at a pressure of 60 lbs. per square inch blow off into the shaft, and this had a rapid cooling effect.

From this table I get the following results :—

The average temperature of the coal seams increase 1° for each 55 feet vertical, nearly. ($54\frac{1}{2}$) feet exactly.

The average temperature of the rocks and metals 1° Fahrenheit for each 69 feet sunk, and the average for both rocks and coal 1°F. for each $61\frac{1}{10}$ feet nearly.

At a depth of 1,433 feet we came upon a bed of white sandstone rock between 50 and 60 yards in thickness, and the temperature in this remained constant 78°F. till we got within 21 feet of a seam of coal 6 feet thick, when the temperature began to rise, and continued to rise till we passed through the seam named above, and through a 2ft. seam some yards below the 6ft. seam, where we recorded the highest temperature, 82°+F. This was the most fiery seam met with. We sank the shaft to a total depth of 1,715ft. into rock, and the temperature was exactly the same as that in the bed of rock at a depth of 1,602ft., viz., 78°+F.

Ten months after the shaft had cut the Trencherbone Mine, I had the temperature again taken in the coal, and warrant below the coal, and found the coal had cooled down 3°F. and the metals $2\frac{3}{4}$°F., at a depth of 560 yards—1,680 feet.

I also applied the same test to the Doe Mine, at a depth, of 1,294 feet, and found the coal had cooled 3° and the

metals 2°F. in twenty months. This looks as if the deep seam was cooling more rapidly of the two.

The temperature of the working place, *i.e.*, the shaft, was generally 6° to 7° below that of the surrounding rocks or coal, but this is not reliable, as it would vary very much according to the quantity of air blown down.

The men and their lights raised the heat of the working place 3° to 4°F. on an average.

All the tests were carefully conducted, and in some cases verified two or three times over.

The holes in most cases were drilled by Burleigh rock drills, driven by compressed air, the exhaust being allowed to escape into the shaft, and it took fifteen minutes to drill a hole 3″ diameter and 3′ 6″ deep in hard sandstone rock. I thought this might slightly raise the temperature of the rock round the drill hole, but as water was used in drilling I think it had no appreciable effect, and to test it I had holes drilled by hand at the same time and the thermometer inserted, but found no difference.

The experiments were conducted as follows:—

The hole was drilled as soon as possible in the newly exposed face of rock or coal. The thermometer was inserted into the drill hole, then dry waste put on it and the hole stopped with clay which had been kept down the shaft till it was of the same temperature as the surrounding measures.

The thermometer used was made by Casartelli, of Manchester, and I have had it compared with a Kew standard thermometer to see that it was correct.

I am sorry that I did not apply a pressure guage to the drill holes, where gas was given off freely, as I have little doubt that it was given off at a very considerable pressure from the way in which it lifted the metals when near a seam of coal, and the great compression may have had an effect in raising the temperature.

From these experiments it appears that the more fiery the mine the higher the temperature of that mine, and in approaching the mine the temperature of the rocks increased more rapidly the nearer we got to the mine and as gas was given off into the drill holes.

I find that at a meeting of the British Association on the 3rd of September, Professor Everett read a report of a committee on underground temperatures. At Folergoch Lead Mines, Flintshire, near Rhyl, they conducted their experiments in a different way to what I have done. They drilled holes 24″ deep at from 1½ to 5 yards from the face; put the thermometer in and plugged the hole, left it in four days, then took it out and read it; re-inserted it and read it again a week later, and in no case was there a variation of so much as half a degree. A slow action thermometer was used.

This was in carboniferous limestone, the shaft top 190 ft. above the sea level, and the deepest working 900 feet below sea level.

The average temperature of the earth is generally about 50° F. at a depth of 50 feet, and at this depth remains constant. The rate of increase in our coal mines, as generally given, is 1°F. for each 60 feet, but it is questionable whether, after a great depth is reached, the rate of increase does not become more rapid. At Rose Bridge, 403 fathoms deep, the average rate of increase was 1°F. for each 56 feet. Mr. Dickinson gives it as 1° for each 55 feet in his report to the Royal Commission. At Clifford Copper Mines, 440 yards deep, they got 100°F. in 1863, and in July, 1864, it fell to 83°, or 17° in 12 months. At Rose Bridge, at a depth of 2418 feet, it was 92°F. At Newtown, at 1715 feet, it was 78°F., a difference of 14° in 703 feet, or 1° for each 50 feet.

The temperature of the earth in this country is estimated to be 98°F. at a depth of 3,000 feet, and increases 4 per cent. at a further depth of 420 feet.

From my experiments it would be 99°F. at a depth of 3,000 feet if it continued to increase at the same rate as in the 1,715ft. sunk through at Newtown.

It seems to me that in making these experiments you may get a very much higher average temperature if you have fiery seams, and a large number of those seams in the shaft, as in this case there are ten seams of coal passed through in 1,100 feet, and as each seam is from 1° to 2° higher than the measures above or below, and in two cases 4° and 5°, it raises the average temperature considerably, and that you would get a much lower average where the seams are more widely separated by thick beds of rock or metal, if the same rule holds good in the measures in other places, *i.e.*, that the temperature of the seams of coal is much higher than the surrounding measures.

I do not know of any observations where the temperature of the coal seams and rocks have been kept separate.

Mr. Dickinson said: This subject is one which was before us, on the Coal Commission, at very great length, and we had observations from almost every available source. Amongst the rest there were some in this immediate neighbourhood; and I find that Mr. Woodward's observations confirm those made by Mr. John Knowles, in some of the collieries adjoining, and also his observation with regard to the coals being higher in temperature than the surrounding rocks also corroborates previous observations. The cause that Mr. Woodward attributes that to has not, I think, been previously stated—that is, that it is through the expansion, of the gas liberated by the coal seam. That is a conclusion which perhaps admits of some consideration before being accepted, because in one part of his paper Mr. Woodward tells us, no doubt correctly, that the expansion

of the air from the air engines has a cooling effect. The expansion of the gas from the coal seam ought, therefore, to have a corresponding effect. Coal seams, however, are higher in temperature than the surrounding rocks, and I almost think the harder the rock the slower it is in giving off its heat. Of course these are rock temperatures. They are but the temperatures of a mine, which may be reduced by ventilation; nor has Mr. Woodward given any hygrometical observations showing how the humidity of the air increases in the deep mines. But in this report of the Royal Commissioners to which Mr. Woodward alluded, mention is made that in the Seaham Colliery, where the recent explosion took place, a greater degree of humidity was met with than in any of the other mines which we had before us. Next to that was the Pendleton Colliery. Then again, lest any one should generalise too much, and say that this great dryness in the Seaham mine caused the explosion to extend considerably, I may tell you that at Risca, where an explosion took place last July, I took hygrometical observations only a few weeks ago, and there the air of the mine was nearly saturated. There was only 2° difference between the wet and the dry bulb thermometers. The return air was actually saturated. The temperature in the Pendleton Colliery with the dry bulb was 77°; with the wet bulb 69°—that is, a difference of 8°; and at the Seaham Colliery, where the observations were taken, the dry bulb showed 78° and the wet 67°—a difference of 11°; whilst at Risca the temperature of the dry bulb was 70° and the wet bulb 68°, and with those temperatures there were drops of moisture falling from the roof of the mine. In the return air, near the up-cast, the temperature of both thermometers was 67°.

The President: I am glad that Mr. Dickinson noticed one point which Mr. Woodward suggested in his paper,

namely, as to increased temperature being caused, apparently, by compression of gas in a coal seam. No doubt if, by mechanical means, a quantity of gas were to be forced into coal, the temperature of the coal might be raised; but the fact of a quantity of gas having been pent up in the coal for many years, or even centuries, could not possibly as a physical fact, raise the temperature of that coal. And if any small opening were made which would tend to liberate that gas, the natural consequence—as another physical fact—of the liberation of that compressed gas would be to lower the temperature, especially if the gas, as must be the case when fire damp exists under very high pressure, were in a state of liquefaction. I do not know how far it has ever been proved that fire damp exists in the coal measures in a state of liquefaction, but in very fiery seams I imagine that must be so: then when a bore-hole or other opening enters the strata, the gas will be liberated, and a remarkable reduction of temperature must ensue. No doubt during the ages which succeeded the deposition of the coal measures very high temperatures were caused by the conversion of the carbonaceous matter into coal, and it may be that some of the heat evolved in that process may have been stored up, and superincumbent non-conducting strata may have kept it in; or, more probably, it may be that the chemical changes not being yet complete, they are still causing some evolution of heat. I would suggest this as the more probable explanation of the heat than the theory advanced by Mr. Woodward, which I, equally with Mr. Dickinson, cannot altogether coincide in. I think the facts mentioned in the paper are exceedingly interesting, and I hope they will be made the subject of future investigation, whenever opportunity is given for it by further sinkings.

ON MARINE FOSSIL SHELLS AT ASHTON MOSS COLLIERY SINKING, NEAR ASHTON-UNDER-LYNE.

By Mr. George Wild.

This subject—the bed of marine shells in the middle coal measure series of Ashton-under-Lyne—is one in which many members of this Society have taken considerable interest, and I therefore have pleasure in bringing under notice the following additional information in connection with it, feeling satisfied that if this bed should prove to be unique, as I believe it is, so far as at present known, in the thick series of the middle coal measures which exist on the western side of Ashton-under-Lyne, it cannot fail to have a highly practical diagnostic value to a Society which combines mining with structural and palæontological geology. And if, in the careful and detailed section taken at the Ashton Moss Colliery Sinking, the palæontological characteristics were added, a most valuable assistance would be provided for those whose duty it may be to explore ground which has been disturbed by faults of greater or less magnitude.

Together with others, I long felt uncertain, in the absence of direct proof, as to whether the bed cropping out in the river Tame, containing *Goniatites*, *Aviculo-pectens*, *Orthoceratites*, &c., was occupying a true position in the measures, the section of which below this bed was thought to be well known.

I consequently had frequent conversations and discussions on the subject with my friends, Messrs. Bailey & Radcliffe, who as well as myself have given it much consideration, and a little over a year ago, accompanied by Mr. John

Aitken, one of the Vice-Presidents of this Society we visited the Tame and made a careful examination of the bed which is to be seen in the eastern bank of the river near the London and North Western Railway Co.'s viaduct where it crosses from the Ashton to the Dukinfield side, near Walk Mill. We were successful in obtaining several fine specimens of *Goniatites*, one or two of *Aviculo-pectens*, &c., and a number of fair specimens of *Orthoceratites* were also met with. I however examined them carefully, and,—well remembering how my friend, Mr. E. W. Binney corrected me upwards of twenty years ago for claiming that *Goniatites* and *Aviculo-pectens* were peculiar to the Bullion coal of Burnley or Foot Mine, of Oldham, belonging to the lower coal measures of these districts, he having found them below the mountain mine,—I expressed my opinion to Messrs. Aitken & Radcliffe on our last visit to the place that the fossils did not agree in all respects.

We discussed the questions as to the continuity of the bed, the probable depth it should be met with in the Ashton Moss Sinking if continuous, and its importance, and the general feeling was that it would form a most valuable datum line from which to calculate the position of the Dukinfield series, viz., the Sod, Great, and Roger Mines.

Feeling anxious lest the bed should be sunk through unobserved, I paid frequent visits to the colliery with a view of making enquiries and examining the shale heaps, but I got no sign or tidings of it until October last, when I had the good fortune to find a shale which appears to correspond accurately with the bed outcropping in the Tame, containing specimens of *Goniatites*, *Aviculo-pectens*, *Orthoceratites*, *Posidonia*, *Discites*, *Turritella*, and fish remains; there is also a thin marble-looking band in it, containing fragmentary shells, which has a somewhat encrinital appearance, showing when prepared in the form

of slips and examined under the microscope forms like those depicted, on enlarged scale, in Sketches 1 and 2. They appear to be Spiny or Echinatous shells in company with the *Spiral Turritella*, while the remains in the original slab exhibit a relation to both Encrinites and Orthoceratites.

The question of these shells belonging to the lower coal measures may, I think, now be considered settled, as the shells found in this sinking agree accurately with those of the outcropping bed which, to all appearance, is continuous, therefore its horizon can be fixed and converted into a datum line.

From a section in my possession, the accuracy of which I have no reason to doubt, commencing at the river Tame where this bed of marine shells is seen, I calculate that the Sod Mine is 208 yards, the Great Mine 275 yards, and the Roger Mine 305 yards below it. Should these distances be correct, and the position of the bed in which these shells exist be accurately fixed at 770 yards from the surface, of which there is some doubt as the shells were not discovered for some time after it was sunk through, the total depth to the Roger Mine would be 1,075 yards, a depth which has not, so far as I am aware of, been attained by a perpendicular shaft. This depth is of course liable to variation in case of faults intervening.

Since writing the foregoing, I have paid another visit to the outcrop in the river Tame, and from observations I find the inclination of the strata to be about 35 degrees, and direction W.S.W., and that the thin coal with its iron stone and shale roof containing shells, crops out in the bank of the river. The fossils which I picked up during this visit, which was only a short one, were *Goniatites*, *Aviculo-pectens*, *Anthracosia*, and *Turritella*, which confirmed an opinion I had previously formed that the *Turritellidæ* were represented.

Mr. Dickinson said that there is one coal shaft, at Gilly, near Charleroi, in Belgium, where a similar depth has been attained to that named by Mr. Wild. In this country, however, we have no such depth worked to in the coal measures, although in the township where he resides the depth now reached is about 1000 yards beneath the surface. The paper has a special interest to many members of this Society. For many years we have been led to believe that these shells, the *goniatites* and others, had never been met with above the Mountain Mine series. That was laid down as an axiom; and when these shells were discovered by, I think, Mr. Green, of the Geological Survey, some years ago, so much doubt was expressed about the situation of this bed in the coal strata of Lancashire, that geologists even imported some large fault as having thrown up the lower measures to the top of the coalfield. That, however, had given way in the minds of most persons, some years ago, and the fact of the fossil bed being sunk through in this Ashton Moss pit must entirely dissipate the belief in any such fault. Another moral I think we may all learn from it is this: that it does not do in Geology to place too much reliance upon a particular fossil that is met with. Fossils are an exceedingly good guide, and generally form a guide by means of which conclusions can be drawn, but unless corroborated by the structure of the rocks, as well as by their surrounding features, Geologists may be led astray. This is one instance where they have been led astray, for many years, simply by fixing a particular fossil down to the bottom of the coalfield.

Mr. Aitken: I think, sir, both geologists and miners will be deeply indebted to Mr. Wild for his observations. It has long been a moot question whether the shells found in the valley of the Tame were there in their natural position, or had been brought up by some dislo-

cation, and so exposed to view. When the discovery was made by Mr. Green it created some little stir in the geological world, and I believe the matter was brought before this Society by Prof. Hull, and discussed by the members. Great doubt was expressed as to whether the discovery really indicated that marine shells were to be found in the higher coal measures, or whether their presence in the position named arose from the circumstance which has been alluded to; and the doubt has, ever since that period, remained. I have, on two or three occasions, in company with Mr. Wild, visited the site on the banks of the Tame, and have thus been able to collect a very considerable number of shells, of the species mentioned in the paper. The *goniatites*, with one exception, I consider are similar to those found in the lower coal measures, and the same may be said with regard to the rest of the fossils. The importance of the discovery made by Mr. Wild—and but for his care and assiduity it would not have been made—cannot be over-estimated. From the information I was able to gather in the course of a visit to the colliery, it appears that the bed was not discovered at the time when the measures were sunk through; but the fossils were subsequently discovered by Mr. Wild amongst the shale on the bank. The discovery is important in two respects: in the first place, it points out that the conclusions which have been arrived at by Mr. Binney and other Geologists that marine shells were not to be found above the lower coal measures will require some modification, as it turns now out that they exist in one instance at least, in the higher coal measures, and the place—the exact horizon—is now fixed. That is important as upsetting a theory which has prevailed for a quarter of a century at least, and in the second the discovery fixes a datum line which will be of the greatest importance to those who are sinking for coal. When these shells are found on new

ground it will be very easy to calculate with certainty the position of the beds below. At Ashton Moss the measures sunk through are untried measures; a great expenditure of money has taken place, and there has been great uncertainty until a very recent period as to the horizon which had been reached for want of such datum line as this bed of marine shells supplies.

Mr. John Greenwood said that, as manager of the mine which contained the fossil shells referred to, it was, perhaps, desirable that he should say something in corroboration of the facts stated by Mr. Wild. First, as to the depth of the sinkings: Mr. Wild calculated the depth of the Roger Mine at 1075 yards. The shaft had been sunk to a depth of 800 yards, and below that there was a bore-hole, which made the total depth below the surface 1050 yards, the mines passed through consisting chiefly of two—one (which they called the Great Mine), 6 ft. thick, proved at 890 yards; and another, the Roger Mine, nearly 4 ft. thick, proved about 935 yards. They were thrown somewhat off their guard in the examination of the beds, in search of the fossils in question, owing to the peculiar nature of the strata passed through, which did not at all agree in other respects (apart from this bed of fossils) with the other strata in the Ashton coal-field. The principal rock characteristic of that field was a bed, about 40 yards thick, below the Sod Mine, and that bed has not been seen at the Ashton Moss Colliery, though beds of similar nature had been passed through. By comparison of the nature of the metals, the depth at which the fossils were passed through was fixed at 750 yards, or thereabouts, but they could not tell to within 20 yards; however, in a few months they would have a second shaft passing through the same ground, and he had no doubt that the exact depth at which the fossil bed lay beneath the surface would be fixed without any difficulty.

"ARCTIC PEAT BOG," RHODES BANK, OLDHAM.

By William Watts, F.G.S.

Read by one of the Hon. Secretaries, in the absence of the Author.

In consequence of reports having appeared in the Manchester and local papers, and also in *Nature*, of the supposed discovery of an "Arctic Peat Bog," at Rhodes Bank, Oldham, I thought the subject would be interesting to the members of the Manchester Geological Society, if laid before them.

I had only one opportunity of examining the section intact before it was partially covered up, but I had several opportunities of examining part of the section before it finally disappeared, and also of studying the nature of the ground in proximity.

Not being able to agree with the opinions of some of the writers on the subject regarding the antiquity of the peat section, I feel justified in setting forth my views.

Position of the Peat Section.

The peat section is 570 feet above sea level. It exists near the source of the river Medlock, at a point where part of the Oldham drainage passes. The section is nearly on a level with the small brooklet, and is near the site of an old mill, which has lately been removed for railway improvements. The brooklet, however, has recently been covered in by a brick culvert, consequently the impure waters have now ceased to bathe the threshold of the section.

The surface of the ground around the section is irregular, and appears to have been stripped of clay and sand in many places—the former for brickmaking and the latter for mixing with lime for building purposes.

Clay has been excavated adjacent to the section, probably for the bricks with which the old mill just alluded to

was built, and may have had something to do with forming its present position.

On the left, as the stream is ascended, rises Oldham Edge to an elevation of 826 feet, and Glodwick on the right to an elevation of about 650 feet above sea level. The valley widens out in gentle undulations until some of the more prominent buttresses of the Pennine range are reached, and as it does so, becomes comparatively level, and the escarpment on the rise ceases within a very short distance of the peat section, which is 14 yards long by 3 yards deep, and reposes nearly at the highest point of the valley, but before arriving at the apex of the watershed.

Thus a tolerably good idea may be formed of the physical features of the ground in which the section is found.

Character of the Peat Section.

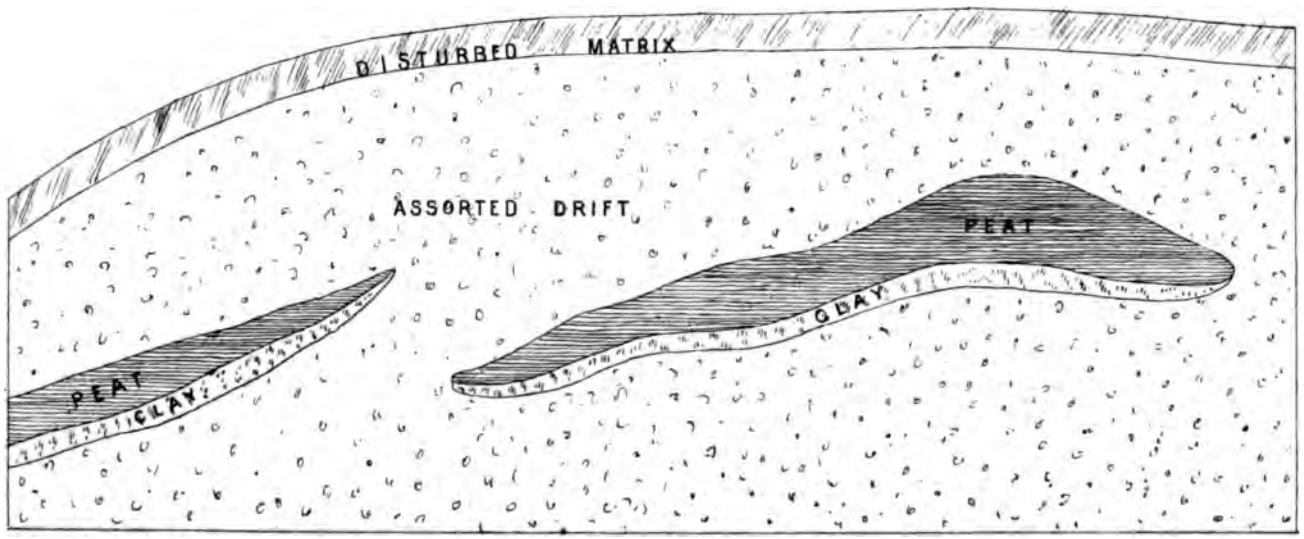
Whatever the character of the deposits above the section may have been, the peat is now embedded in arenaceous matter, *and not in typical boulder clay.* The true boulder clay, however, is found hard by, but the coarse *debris*, of which the section is composed, has been re-assorted by the agency of water, and relieved, to a great extent, of its argillaceous matter.

When the re-assorting here alluded to occurred, we have no precise datum to guide us, but in my opinion it was subsequent to the uprising of the land since the glacial epoch.

The peculiar position of the peat renders it extremely probable that it was formed in a depression of land, and that the coarse matrix surrounding it was subsequently washed in by the agency of water, until filled level with the surface of the adjacent ground.

A thin layer of dark blue clay, fairly unform in colour and composition, lies beneath the peat throughout its entire length, and forms its *underseating.* This clay, in which, at a later date, the vegetable matter secured root-hold, could only have been formed in a depression of land, where water, which removed it in suspension, was brought to rest.

DIACRAM OF PEAT SECTION NEAR OLDHAM.



It would be bold to assert how long the peat was in forming, as so much depends on the vitality of plant life, and on favourable atmospheric conditions, extending over a series of generations of the living plants.

Mr. Nield, who claims this section to be unique, bases its antiquity mainly on the finding of fragmentary mosses in the peat, which are said from microscopical examination to be of arctic origin; but fragments of mosses, and larger rootlets of other plants, together with chips of beetle's wings, all in a tolerably good state of preservation, do not indicate such a great age as would be demanded if it had been formed in the *pre* or *mid*-glacial epoch.

The hypothesis declaring this section to be of arctic origin is, I think, based on insufficient evidence, inasmuch as it ignores the probable chemical changes which peat beds undergo when in a state of decomposition under salt water, or in a matrix likely to prevent the free escape of gases during such decomposition; and also ignores the two factors, *denudation* and *deposition*. Indeed the physical character of the section and its surroundings appear to have been made subservient to what the vegetable matter contains.

The finding, however, of essentially arctic mosses in the peat proves only that a colder climate existed when they grew, and determines nothing of surrounding glacial conditions; as in Britain at present, we need only ascend high enough to find arctic climatic conditions without glacial phenomena.

Evidence depending on outward conditions so precarious should be accepted cautiously, and something more tangible than a fragile moss is needed to stamp the section as a veritable "Arctic Peat Bog," which, so far as I am aware of, is unknown in the English *drift*.

The accompanying sketch represents the section as I first saw it.

The manner in which the peat is deposited is remarkable. On the right hand it terminates very abruptly, is haunch-backed in the middle, and on the left wedge-shaped, and severed from that on the right by the interposition of coarse *debris* similar in character above and below.

The two beds do not incline at the same angle, and it is difficult to believe them contemporary deposits, unless they subsequently parted company, which I maintain has been the case.

The peat is dark brown in colour, and not nearly so black as some I have seen. This difference is probably owing to the vegetable humus having been absorbed, more or less, by the surrounding arenaceous matter, which is charged with small granitic boulders, rounded and sub-angular, intermixed with sandstone grits of local parentage.

The uppermost layer, about 12 inches in thickness, is affected by contact with the surface, and is not nearly so compact as the material beneath. It is also more clayey.

The relation the Peat bears to the surrounding Matrix.

Having described the section generally, I will now refer to it with a view of ascertaining the conditions under which it was probably formed.

In the first place, the two lumps do not appear to have been formed in their existing position, which is an unnatural one for the growth of peat, the plants forming which require so much moisture to sustain and nourish them.

Judging from its present position, the peat was formed in a shallow pocket of land, at no great distance from where it now reposes; and as the brooklet altered its course, from time to time, and became wider and deeper, the matrix now covering the peat was carried forward by its agency and re-assorted, covering the peat from further molestation up to the present. The separation of the peat, transversely,

indicates an occasional flooded state of the stream before the valley assumed its present contour.

It is equally evident that a slip has taken place towards the left of the section; and to me it is quite clear that the two pieces are detached from a larger mass which once existed in the valley at a higher level, and, therefore, must have slipped through the undermining of the brook, or some other aqueous agency.

The section is too small to show whether any cracks were produced during the slipping movement. Indeed, if such were made, they would soon be obliterated by the infiltration of water conveying precisely the same kind of matrix for refilling to that surrounding.

The whole face of the section presents a hard compact structure, the result of gravelly material having been deposited under water and subjected to infiltration, which assists calcareous and silicious particles to cohere.

The Evidence of Peat Mosses.

As before stated, the evidence which mosses afford to decide the age of the peat section should be regarded with much caution, as they are to be found represented in nearly all northern and temperate latitudes of our globe.

Evidence is also wanting as to the lapse of time required to change mosses into peat.

The principal mosses found in the peat are *Hypnum fluitans*, *Hypnum nitans*, and *Hypnum sarmantosum* or *Hypnum cordifolium*.*

These specimens of mosses are well represented in our flora of mosses at the present time.

Hypnum fluitans is very common in the neighbourhood of

* Dr. Braithwaite, to whom specimens of these mosses have been sent for examination, declares *Hypnum sarmantosum* to be *H. gigantium*, which may be found on the Lancashire coast. Since the above sentence was written, Dr. Braithwaite's examinations have been made known, and nearly perfect specimens of mosses have been found, thus proving the section to be of recent origin.

Manchester, in bogs and marshy places; *Hypnum nitans* in bogs in Scotland and in the north; and *Hypnum sarmantosum* on wet, Alpine rocks, in Scotland and Wales.

The stems are much denuded of their leaves, and the latter much split and jagged; in fact, there is scarcely an entire leaf to be found, although their nerve structure is well preserved.

If the section were formed in the glacial epoch, a long time must be required to decompose mosses to unrecognisable constituents of peat. Assuming a depression of the land to have taken place at the rate of 2½ feet per century, as stated by Sir C. Lyell, it would occupy 4000 years for the submergence of 100 feet beneath the sea, which we are told was the case after the peat was deposited, and assuming a similar rate for re-elevation, we arrive at 8000 years as the minimum time the peat must have been under water. If now the same datum be applied with reference to its present elevation (570 feet), we get a further 22,800 years since the peat left the sea level which would give a total of 30,800 years as its minimum age if formed in mid-glacial time, as alleged, after which lapse of time one would not expect to find mosses and other rootlets, together with beetles' wings, in a tolerably good state of preservation. It is therefore evident that mosses alone are not sufficient to decide the matter in favour of the mid-glacial theory.

And, again, apart from the severity of the glacial climate for the production of peaty matter, I fail to see how the section escaped destruction by stranded icebergs impinging on the floor of our sea coast as they moved inland, or from shore ice as it slid into the sea, or even by the ordinary tidal wave action.

Conclusion.

The peculiar position of the peat—in detached masses—renders it extremely improbable that it grew in its present position.

The two beds are not on the same horizon, as would be the case if undisturbed since first laid down, and it is scarcely likely that the character of the matrix resting on the peat would be precisely the same as the matrix beneath it, if deposited after the peat was formed.

The matrix is arenaceous matter which has been assorted by the action of water, probably more than once, and not undisturbed drift.

The peculiar position and circumstances satisfy me that the peat was formed in a depression of land, on a sloping surface, and that the brook has undermined the section, from time to time, and caused it to slip from its natural bed, and subsequently surrounded the peat with washed and re-arranged arenaceous material and not with typical boulder clay. I see no difficulty in distinguishing between the true drift and assorted gravelly material in this instance.

As many winged insects begin life in water, and as peat forms a good harbour for the insect tribe, no surprise need be felt at beetle's wings being found in it, and which I consider is also against its arctic origin.

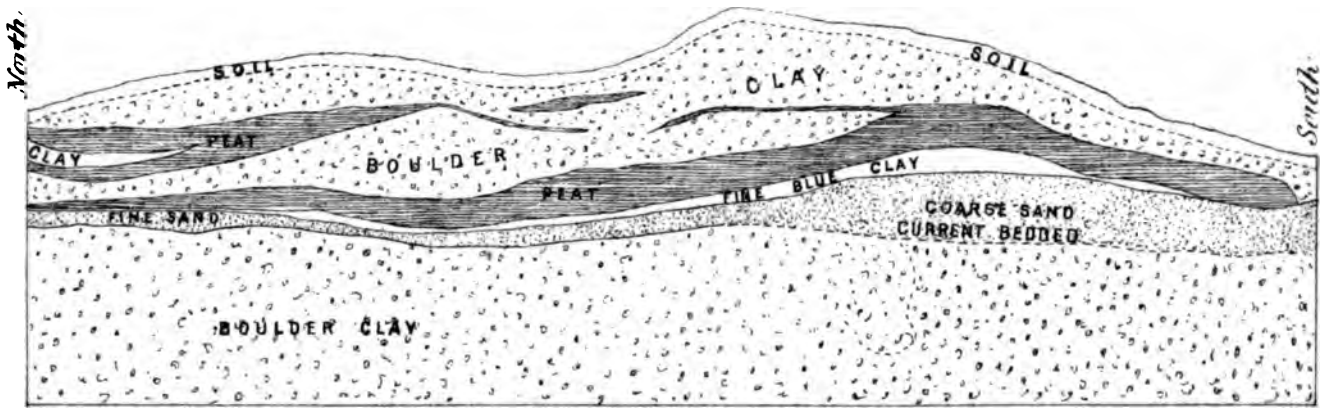
Mr. Plant said that he was very glad Mr. Watts' paper had been brought forward. From the first announcement of the discovery he did not believe in the conclusions which Mr. Nield and others appeared to have arrived at. He had not been able to visit the place, but relying upon a discussion in *Nature*, as to its soundness or want of soundness, he thought it had been satisfactorily shown to be unsound. There was no such thing, nor the probability of such a thing, as an "arctic peat bog," coeval in time, with the boulder clay. Mr. Nield claimed it as being unique, but he (Mr. Plant) had been shown at Heaton Norris thin layers of peat existing within the true boulder clay but of much later date than the clay. The position was due to landslips.

Mr. Aitken said he also was very glad that the paper

had been read. Mr. Nield was kind enough to draw his attention to this bed of peat, but he was unable to visit it at the time. Mr. Nield, however, showed him the section he had made, and stated that the drift overlying the peat was continuous with that of the surrounding district, which was in his opinion undoubtedly of glacial origin. Not having had an opportunity of seeing the supposed arctic bog, he was unable to discuss the matter as he otherwise might have done, but agreed with the writer of the paper and Mr. Plant, that it was impossible for a peat bed to be formed, as described, in a bed of glacial drift. As he understood it, Mr. Watts had come to the conclusion that the bed in which the peat was found was re-arranged drift washed down from the hills above, accompanied by some slight landslips, and that the peat had accumulated in a hollow and been gradually covered up by the washings from the surface on the higher grounds. This, he (Mr. Aitken) thought, gave a reasonable explanation of the whole matter.

Mr. G. Hollingworth said he had visited the place in question, and made a careful examination, and could not dispose of the matter in the same easy way that Mr. Plant and Mr. Aitken seemed to do. In his opinion, the peat was interstratified, in its natural position, between the boulder clay. The peat, as shown in the section, was in position upon a bed of sand which was continuous to the east, thickening out as had been proved by excavation. The peat, he considered, occupied the place of the sand. About 300 yards eastward, a bed of sand was found interstratified between two boulder clays in a sort of pocket, and all over the district, for miles, the same thing was to be seen—sands covered by drift. Then as to the slipping theory, there was, so far as he saw, not a trace of a slip anywhere; and the under surface of the peat, or rather the top of the clay, was continuous backwards and might be traced, for perhaps twenty yards, at right angles to the section.

SECTION OF BOULDER CLAY WITH INTER-STRATIFIED PEAT, RHODES BANK, OLDHAM.



Scale:- 8 feet to an inch.

Geo. H. Hollingworth.

Mr. Nield had not decided that the peat was arctic from a microscopical examination of his own, he placed some of the mosses found in the hands of Mr. Whitehead, a competent muscologist, who recognised one or two species of decidedly northern character, and they were now in the hands of the Rev. J. Ferguson, of Brechin, an authority in muscology, for further examination. The blue clay beneath, which Mr. Watts admits was continuous, looked as if it might be the soil on which the peat grew.

The section (given opposite), which he made from his own observations, and which is plotted to scale, would be seen to differ very much from Mr. Watts' diagram.

Mr. Horsfall said that Mr. Nield, in coming to the conclusion he had with regard to this deposit, had betrayed anything but haste. He had, in fact, been exceedingly deliberate in every step he had taken. He had no theory to found upon it, nor did he care to bolster up any theory that suggested itself to him when he commenced the examination. He invited no less than half a dozen eminent geologists, two or three of them professors, who made an inspection; and the only one who offered any objection was Mr. Morton, of Liverpool. Mr. Nield was anxious that as many as possible should see the section, and on a subsequent occasion, nearly a hundred persons were present. Mr. Nield specially invited any person who had objections to offer to state them then, in order that an investigation might be made before the place was covered up. Mr. Watts was present, and made no objection. It was after Mr. Nield read his paper later on in the evening that Mr. Watts raised his objection. Mr. Nield replied, and he (Mr. Horsfall) thought disposed of it satisfactorily.

Mr. Wild said that no doubt Mr. Hollingworth, in getting up his section, took all the pains he possibly could, and the party who were there at the time Mr. Horsfall spoke of would also take all the pains they could in examining the

peat bed; but it was admitted that one end of the section of peat was partially covered up; and it was certain that at the end which was covered up first there had been a decided slip—there was a clay bank and no peat behind it.

Mr. AITKEN: you noticed that your yourself?

Mr. WILD said he did; and he even then struck a pick into it. He (Mr. Wild) also went on the top to see whether the turf had come three or four feet: and his opinion was that it had come over the sand altogether, from higher up the slope. It is a slickenside in a sort of clay bank,—a slip, and he was positive there was no bog behind it on the same level.

A VISITOR stated, with regard to the mosses found in the peat-bed, that the muscologists who had examined them had almost made up their minds that one doubtful species, supposed at first to have been *Hypnum sarmentosum*, was really *Hypnum cordifolium*, which was certainly not Arctic. That, however, did not militate against Mr. Neild's theory as to the origin of the bog.

Mr. AITKEN said that Mr. Neild had been kind enough to show him a number of elytra and other parts of insects, which were comparatively well preserved. He also showed him several examples of moss, under the microscope, of which the leaves were in a very perfect condition. In many cases he could see the structure almost as in a recent moss. This struck him at the time as being very inconsistent with the idea that the peat was of glacial origin—many thousand years old,—for, after the lapse of such a period, it was hardly possible that either the leaves of the mosses or the remains of the insects could have been so perfect. At the same time he had every confidence in Mr. Nield's desire to arrive at a correct conclusion, and knew that he had paid great attention to the matter. He regretted that it had not been in Mr. Neild's power to attend the meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART III. VOL. XVI. SESSION 1880-81.

An ORDINARY MEETING of the Members of the Society was held on Tuesday, the 21st December, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOSEPH DICKINSON, Esq., F.G.S., Vice-President, in the Chair.

Mr. E. Leader Williams, M.Inst.C.E., Queen's Chambers, John Dalton Street; Mr. H. Stott Grimshaw, Stand Lane Colliery, Radcliffe; Mr. C. E. Jeffcott, Colliery Proprietor, Sheffield, were elected ordinary members of the Society.

The following additions to the Library, received since the last Meeting, were laid on the table.

Belfast Natural History and Philosophical Society: Proceedings for Sessions 1878-9 and 1879-80—*From the Council.* Institution of Mechanical Engineers: Proceedings No. 3, 1880—(Barrow Meeting)—*From the Council.* Liverpool Geological Society: Proceedings, Part II., Vol. IV.—*From the Society.* Midland Institute of Mining, Civil, and Mechanical Engineers: Transactions, Part 51, Vol. VII.—*From the Council.* Mining Institute of Scotland: Transactions, Vol. II., Part 7—*From the Council.* Bulletin of the Museum of Comparative Zoology, Cambridge, U.S.A., Vol. VI., Nos. 8-11; and Annual Report of the Curator, 1879-80—*From Alexander Agassiz.* Bulletin of the U.S. Geological and Geographical Survey of the Territories: Vol. V., No. iv.—*From Dr. F. V. Hayden.*

PURCHASED.

Coal and Coal Mining, Weales Series, 5th Edition, by W. Warrington Smythe, M.A., &c. Geological Magazine, Nos. 197-8.

BLASTING IN MINES, WITH WATER IN THE BORE HOLES.

By Mr. James Tonge.

Mr. Hulton, of Hulton Park, on the 5th October last, drew my attention to a letter in the *Times* newspaper signed F.A., C.E., setting forth that the danger of explosion through the use of explosives in mines would be effectually removed or largely decreased by the insertion of water cartridges in the holes, as in use in the vicinity of Barnsley.

I was at first inclined to think the results recorded too good to be true, but on consideration, I determined to make a number of experiments to test the truth of the statements contained in the letter. Being somewhat encouraged, but not fully satisfied, with my first experiments, I endeavoured to find out the colliery where this system of blasting was in use, but was not successful. I, however, soon learned that Mr. Macnab was complaining that such a letter had been published without his permission, as it related to a principle patented by him, though not yet made public.

I observed in last Saturday's *Colliery Guardian* there was a prospectus of the Macnab Patent Safety Hydraulic Cartridge Company, Limited, formed to acquire and work the letters patent granted 9th August, 1876, No. 3150, to Mr. James Macnab, of 27, Southampton Buildings, Chancery Lane, for the invention of improvements in getting coal and other minerals, blasting and disintegrating rocks, &c., &c.

It would appear from this, that the principle referred to in the letter to the *Times* is identical with that patented by Mr. Macnab, with which I was not previously acquainted.

The following are descriptions of the mode of procedure and results of experiments which I made, viz. :—

EXPERIMENT 1 was made in the floor of the half-yard coal, a very strong warrant. The shot was what is termed a bench shot, the borehole 3 ft. deep and 2 ins. diameter. No cutting had been done, but short props had been fixed along the desired line of fracture to assist the warrant in breaking off.

The powder cartridge was 14 ins. long and 2¾ ins. diameter, and weighed 2½ lbs.

The water cartridge consisted of a pasteboard tube 9 ins. long and 1 in. diameter; being much less than the borehole, the ordinary stemming was put round the powder cartridge as well as possible, and also about 2 ins. in front of powder to avoid a cavity. We then put in the water cartridge, and upon that the ordinary stemming.

Result.—The result of the explosion was a very large quantity of earth lifted, considered by the colliers to be more than usual from same quantity of powder; there was no flame visible nor sparks, but there was apparently a light in the hole which shone for a little space near the hole like a room lighted on a dark night by a distant flash of lightning; the flame, however, did not pass out of the hole.

This experiment was supposed to be a good one, both as to quantity of material lifted and flame subdued.

EXPERIMENT 2.—This and following experiments were made in Trencherbone coal. The place a bay, *i.e.*, on face of coal, 6 yds. wide; powder cartridge, 8 ins. long, 1½ ins. diameter; water cartridge, tin case, 6 ins. long, 1⅛ ins. diameter, with wood plug at one end, the tin end being placed next to powder and close to it.

Result.—Usual quantity coal blown; no light at all visible; end of water canister next to powder uninjured, but plug gone from other end and case emptied of water.

This we could not explain; we were at a loss to think how the plug could be sent out without the other end being driven in. This result doubtful so far as theory goes.

EXPERIMENT 3.—Place, an end; but the shot was merely a ribbing shot to get down a piece of coal 4 ft. wide; holed underneath, 3 ft. 6 ins.; drill hole, 2 ft. 11 ins., 1½ ins. diameter; powder cartridge, 8 ins. long, 1¼ ins. diameter; water cartridge, 7½ ins. long, 1¼ ins. diameter, of tin, and placed in hole with end containing wood plug next to powder.

Result.—Fair quantity coal blown; tin case blown out with not the least mark of injury—wood plug and water exactly as when put in, except that plug might perhaps be a little further in case, and other end slightly bulged out. Flame and sparks distinctly seen.

EXPERIMENT 4.—Without water. Place, an end, width, 6 ft.; holed underneath, 2 ft.; powder cartridge, 12 ins., 1½ ins. diameter.

Result.—Coal blown down, 6 ins. behind borehole, but 6 ins. less than side cutting; stemming and blazing fuze shot past us at a distance of 20 yards.

This charge was overpowdered owing to an inadvertence on the part of the person putting in the charge. Having put in the powder he threw in some stemming before we could stop him, and the moment we did so he pulled at the fuze to withdraw the charge when it slipped from the cartridge leaving the powder in the hole.

To guard against accident to any person we put a very small additional quantity of powder in the hole and fired, with the result named.

EXPERIMENT 5.—Place, a bay, 6 yds. wide; holed underneath, 3 ft. deep and 9 ft. wide; powder cartridge, 9 ins. by 1¼ ins.; water cartridge, tin, placed in hole with tin end next to powder.

Result.—Usual quantity coal down, large body flame and sparks seen; tin end out of case when found, and case crushed in one place apparently by large piece of coal falling upon it.

The conclusion drawn was, that the flame had not got to the water but that the canister had come out of the hole uninjured and had afterwards had the end knocked out.

EXPERIMENT 6.—This and next experiment in "Yard" Mine. Place, a bay, 30 yds. wide; holing, 12 ft. wide, 2 ft. 6 ins. deep; drill hole, 2 ft. 6 ins. deep, and 1¼ ins. diameter; powder cartridge, 6 ins. long, 1¼ ins. diameter 5 oz.; water cartridge, 6 ins. long, 1 in. diameter.

Result.—Usual quantity coal blown; bright shining near hole, but no actual flame visible; sparks extended 6 ft. from hole.

EXPERIMENT 7.—Place and conditions similar to last in every respect.

Result as in last case, except that sparks did not extend more than 3 feet from drill hole.

EXPERIMENT 8.—This and following experiments in "Trencherbone" Mine. Place, an end, 4 yds. wide; holed underneath, 2 yds. wide, and 3 ft. deep; cut on one side, 1 ft. 6 ins. deep; drill hole, (placed 2 ft. 6 ins. from cut side) 24 ins. deep; powder cartridge, 8 ins. long, 1¼ ins. diameter; no water cartridge.

Result.—Very little coal down; great number of sparks flew 6 feet across road.

EXPERIMENT 9.—Place, a bay, 10 yds. wide; holed underneath, 6 ft. wide, and 2 ft. 11 ins. deep; drill hole, 2 ft. 11 ins. deep, and 1½ ins. diameter; powder cartridge, 9 ins. long, 1½ ins. diameter; water cartridge, paper.

Result.—A *few* sparks; much smoke; moderate quantity coal.

EXPERIMENT 10.—Place, a bay, 5 yds. wide; holed under-

neath, 5 yds. wide, and 3 ft. deep; drill hole, 2 ft. 6 ins. deep, and 1½ ins. diameter; powder cartridge, 8 ins. long, 1½ ins. diameter; water cartridge, paper, 7 ins. long, 1 in. diameter.

Result.—Good fall of coal, very many sparks shot across place, and much smoke given off. In this case it was supposed the water had escaped from the cartridge during its insertion in the hole.

EXPERIMENT 11.—Place, a bay, 18 yds. wide; holed underneath, 6 ft. wide, and 25 ins. deep; drill hole, 25 ins. deep, 1¾ ins. diameter; powder cartridge, 8 ins. long, 1½ ins. diameter; no water cartridge.

Result.—Coal as usual; much smoke; very large quantity sparks shot across place.

EXPERIMENT 12.—Place, part of bay, 30 yds. wide; holed underneath, 6 ft. wide, 2 ft. 3 ins. deep; drill hole, 2 ft. 3 ins. deep, 1½ ins. diameter; powder cartridge, 9 ins. long, 1 in. diameter; water cartridge, tin, 7 ins. long, 1 in. diameter; placed with plug outward.

Result.—Large quantity coal down; great number sparks; much smoke; water cartridge bent, and small hole in end next to powder, but questioned whether flame had got to water.

EXPERIMENT 13.—Place, an end, 4 yds. wide; holed, 2 yds. wide, 3 ft. deep; drill hole at end, 3 ft. deep, 1½ ins. diameter; powder cartridge 8 ins. long, 1¼ ins. diameter; water cartridge, tin, with tin end towards outside of hole and nothing at other end except tallow.

Result.—Good fall of coal; little smoke; not a light or spark visible; case crushed very much.

EXPERIMENT 14.—Place, a bay, 6 yds. wide; holed underneath, 8 ft. wide, 3 ft. 9 ins. deep; drill hole on one side, 3 ft. deep, 1¼ ins. diameter; powder cartridge, 14 ins. long, 1¼ ins. diameter; water cartridge, tin, 7½ ins. long, 1¼ ins. diameter.

Result.—Water cartridge blown out with stemming, very little damaged, and water still in; very little coal down as sprags had not been taken away. No flame seen but a great number of sparks.

EXPERIMENT 15.—Place, an end, 4 yds. wide, being taken downbrow; holed underneath, 3 ft. deep; drill hole, 2 ft. 5 ins. deep, 1½ ins. diameter at one side of place, and other side cut 38 ins. deep; powder cartridge, 9 ins. long, weighing ¾ lb.; water cartridge, paper, 6 ins. long, ¾ in. diameter.

Result.—Coal blown down well; no flame; and only 2 or 3 sparks.

EXPERIMENT 16.—Place, a bay, 12 yds. wide; holed underneath, 15 ft. wide, 2 ft. 11 ins. deep; drill hole, 2 ft. 9 ins. deep, 1¾ ins. diameter; powder cartridge, 8 ins. long, 1½ ins. diameter, 5 oz.; water cartridge, paper, with small quantity of a fire-extinguishing fluid, (CO_2?) manufactured by Mr. Jones, of Bolton. This cartridge leaked at first and afterwards burst in hole.

Result.—Shot did good work; many sparks shot out 4 feet.

EXPERIMENT 17.—Place, an end, about 9 ft. wide; holed underneath, 9 ft. wide, and 2 ft. 9 ins. deep, and side cut; drill hole, 2 ft. 3 ins. deep, and 1¾ ins. diameter; powder cartridge, 8 ins. long, 1½ ins. diameter; water cartridge, tin, (the same as used in No. 14 experiment, it not having been damaged), 7½ ins. long, 1¼ ins. diameter.

Result.—A large quantity of coal down, but a large number of sparks issued from hole.

EXPERIMENT 18.—Place, an end, (same as No. 17) holed all across, and 3 ft. deep at one end, nothing at the other; drill hole, 2 ft. 11 ins. deep, 1¾ ins. diameter, placed 4 ft. from cut side, and 23 ins. from top of coal; powder and water in one double cartridge, 12 ins. × ⅞ in., with tin division in centre.

Result.—Little coal; little smoke; and not a spark or a glimmer of light.

[illegible]

[illegible]

Experiment 3.—[illegible] [illegible] the wire: [illegible] [illegible] the wire [illegible] [illegible] the [illegible]: [illegible] the [illegible] [illegible] [illegible]

they do not *increase* the quantity of coal blown, they certainly do not lessen it; whilst they in some cases certainly extinguish flame, and diminish smoke.

2. That the advantages resulting from their use are dependent upon 2 classes of conditions, viz., ([a]) those of the coal mine itself, over which there is not full control, nor about which is there always exact knowledge; and ([b]), the material, form, and character of the water cartridge itself, which is *wholly* within control.

3. In respect to the cartridge it would appear that to answer its end most fully it should be strong enough to allow of being stemmed without bursting, and yet at the end next to the powder weaker than surrounding strata, so as to admit as much flame as possible *into* the water. The cartridge should also, it appears to me, contain both powder and water in one case separated by a very weak barrier.

By this plan, shown below, the powder is as far as possible confined to the water cartridge.

4. While careful experiments and study of the conditions of a mine, may enable us to adopt a water cartridge that shall in some instances, perhaps in many instances, be very useful in lessening flame, I am inclined, in the absence of other and more reliable testimony, to think we can not fully rely upon it at all times; and as the failure might be at a critical moment, I think we shall do well still to be on our guard even if adopting them.

Mr. Hall said: So far as I have been able to see, I think we have not got very far yet; though it may be we are on the right track. I believe, myself, that there will be very much greater chance of succeding with dynamite than with gunpowder. The author of this paper seemed to assume that by putting water into the hole, with his gunpowder, he would get more power. There, I think he is wrong;

because with either gunpowder or dynamite, the closer it is stemmed the more work it will do. I do not agree with Mr. Tonge in thinking that he will derive any benefit from any hydraulic pressure; he will rather lose power through his stemming not being tight, in consequence of water being in the hole along with the powder. I may say that I have tried a few experiments myself both with dynamite and with gunpowder. We tried gunpowder actually in the water and not at the end of the cartridge, as the author of the paper seems to have contrived his experiments; but we were not very successful. I believe, however, that the experiments are well worth pursuing; and I know that Prof. Abell—than whom, perhaps, no one is more competent to give an opinion—thinks there is very great hope of succeeding in getting blasting done without flame, by means of dynamite and water.

The CHAIRMAN (Mr. Dickinson) said: I think it is a year or two ago since I first entered into a correspondence with Mr. Macnab on the subject of the compressed air cartridge, from which some people hoped for good results. The reply, however, which I received from him upon the subject convinced me that although he was, perhaps, the father of the invention, he had given up hopes of any great success from it; but he stated that he had since discovered the water cartridge, from which he expected good results; and he added that upon his return from Paris, where he then was, he hoped by means of that water cartridge, to—as he forcibly expressed it—"make the thunder roar." Up to the present time it can scarcely be said that the thunder has been "made to roar" with the water cartridge, but perhaps it is likely to be none the less efficacious on that account, as often a slow procedure in bringing into operation any important change produces the most successful results. Having also officially had my attention called to this water

cartridge in the month of September, I again communicated with Mr. Macnab, and enquired of him if there was any mine in the country where I could see it in operation. He replied that, in consequence of other engagements, he had not been able to give that attention to the subject which he would like to have done, but he would do so shortly. I then incidentally mentioned to him that at a mine in Sussex—the Sub Wealden—they had got a good number of these tin cases for the purpose of working the mine by means of the water cartridge, but that on experimenting, they had failed to produce any useful result and had given it up. That, I may say, is a mine where there is no fire, and the object in using the water cartridge was economy, the expectation being from the expansion of the water into steam to produce a more powerful effect. Then, when these letters appeared in the *Times*, alluded to by Mr. Tonge, I had some further communication with Mr. Macnab, and I enquired from him as to what colliery it was at Barnsley where the experiments were being made. I wrote to my colleague, Mr. Wardle, upon the subject, and he informed me that, so far as he was aware, no experiments had been made at Barnsley, but that near Sheffield, some experiments had heen made in this manner: "Cartridges of powder were put in the holes, and on the top a water-tight tube, the tamping being done on the top of these water tubes. This, perhaps, prevented flame, and the water, to a great extent lessened the quantity of smoke, but the trouble of carrying these cartridges about and using them prevented their being generally applied." He says also that Reuss's compressed air cartridges were also tried, but without success. The thing appears to be making its way, to some extent, by experiment, but it is clear we have not yet got at such certain results as will enable us to say that the invention is satisfactorily introduced in practice. Mr.

Tonge, in his paper, has given us the result of his experiments. I do not quite gather from him whether he considers the tin cartridge or paper to be the best, for it is very clear much will depend on getting the water enclosed in some material that will enable the contact of the flame with the water to be always successfully accomplished. Mr. Tonge gives several cases where the cartridge was not exploded at all—where the water was left intact—and some in which he thinks it had escaped before the shot was fired. Then again, he gives us the results. In one or two I think there was flame clearly observable; in some there was no flame; in others there were sparks. Of course, if the water cartridge will lessen the volume of flame, it will be advantageous, but if there be any flame left I still consider that as an explosion is possible where there is inflammable gas, it will be precluded under the Act, as not being safe, for although it may be but a small flame, it may be sufficient to light the gas, and the Act prohibits any explosion being risked where it is not safe. It occurs to me that there may be other advantages in the water cartridge besides the advantage in quelling flame and smoke, and also, perhaps, by the expansion of water into steam, giving more explosive power. It is well known to miners that in their ramming of shots, many shots go off unaccountably. Some of the miners, in ramming shots, when they have gone off, have been under the impression that either the stemmer or part of the stemming had cut through the fuse, and that although the flame had not reached the top of the fuse before the shot went off, the fuse had fired down to the powder, consequent upon the cutting and ignition of the fuse by a spark. Then again, in the ramming of a shot, it is said every material, unless it be perhaps rock salt, will by a blow which may be readily given, emit sufficient heat to fire powder. It may be that the blows of a stemmer

may, in some instances, cause sufficient heat to ignite powder. We also know that, in the compression of air, heat is given out freely. A little while ago, a very interesting paper was read before this society by Dr. Angus Smith, in which he, by means of his fire-damp indicator, showed that by compressing air mixed with gas it was possible to elicit a spark. Since that time, Mr. Dancer, the optician, of Manchester, has made a more perfect instrument, by means of which the compression of air elicits a spark at almost every experiment without the presence of any gas. If a cushion of water could be put between the stemming and the powder, one of the means of communicating heat to the powder would be cut off; so that an advantage which has not hitherto been claimed for the water cartridge, may really be inherent in it.

Mr. MACNAB congratulated Mr. Tonge upon his perseverance in conducting the experiments which he had described, but regretted that he should have been led astray by the letter which appeared in the *Times*.* He (Mr. Macnab)

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* Mr. Macnab summarizes his conclusions regarding the experiments described by Mr. Tonge:—

1st. The use of *tin-plate* tubes was an insurmountable mistake, leading to all the inefficiencies and difficulties encountered. This tube of water became a species of solid incompressible bolt when subjected to the *equal* pressure of the explosive gases under such conditions.

2nd. The *paper* tubes were correct, but the description of paper is important. The *very best water-proof cartridge paper* should be used, as if not, absorption of the water goes on rapidly and will lead to failure.

3rd. The volume of water used was inadequate, and the diameters of the water-tubes were nearly all too small for the diameter of the bore-holes—they should have filled them well, allowing only about $\frac{1}{8}$in. for the flash from a squib of powder to penetrate to the charge; or, instead, the use of a flat rolled leaden fuse to ignite the charge.

4th. The ordinary Bickford fuse, which was used, occupied too large a space alongside the water-cartridge, and consequently created too great an air-space for efficient results.

5th. A pellet of soft clay should, in every instance, be used in front of the water-cartridge, which, in these experiments, I believe, was not used at all. This is important, as the soft clay plugs the outlet to all sparks and escape of pressure.

claimed to be the inventor of the system of blasting with water and of the water-cartridge. In his experiments, however, he had never used tin (tinned iron), but he had used some cases made of zinc, though on a different principle from that described by Mr. Tonge; for a tin case filled with water and sealed at both ends became a solid body, and therefore, useless, water not being compressible. After reading a letter which he had addressed to the editor of the *Colliery Guardian* and which appeared in that paper in reply to the letter signed "F.A., C.E." in the *Times*, Mr. Macnab said that the trials made with his water-cartridge everywhere had been successful, in one case starting the coal 15 ft. on each side of the shot—in all 30 ft., and that, without smoke, flame, or sparks. He then read the following paper:—

BLASTING WITH WATER.

By Mr. James Macnab.

I sincerely thank you for this kind invitation to be present at this meeting. In consequence, however, of the short notice I have had, I am, I regret to say, all unprepared with such a paper as I should have wished to read this afternoon. I shall, therefore, only be able briefly to touch upon the history of my experiments and the pure principles of the invention, to the exclusion of mere details as much as possible.

With these few preliminary remarks I will proceed to observe that my attention and time, for some years, have been almost exclusively employed in investigating the process of safely mining coal,—firstly, with compressed air and water. I may here take this opportunity of stating that I claim to be the original inventor of the "pneumatic cartridge," combined with water. It was while experiment-

ing in this field that I was led, by analogy, to discover my more recent process of blasting with water.

Primarily, as in the field of compressed air, my one object was to obtain safety—safety in the most fiery mine from the flash and flame of the shot, the danger from which has brought about the restrictions on the use of explosives in such mines. This was itself a sufficiently difficult and ambitious aspiration, but as I proceeded with my experiments, a wider field of improvement opened out before me. What I accomplished I will now endeavour to inform you of categorically, but briefly.

First, the prevention of flash, flame, and smoke. I first constructed an instrument which I call a "mining gun," being almost equivalent to a central-fire breech-loading piece of artillery. This little gun (*showing a detonator*) is a simple modification of it. The powder charge was encased in the breech, and the barrel filled with water to the muzzle and corked; it was then placed in a slightly "dipping" hole filled with water and jammed into its mouth; then shored up by a special apparatus to hold it to its work and prevent its recoil. In the case of a "rising" hole, a water cartridge was used instead of loose water. The breech chamber charge was fired by a striker, actuated by a spiral spring, to which was attached a wire-line, similar in action to a detonator—*(action of firing.)* The coal was blown down without flame, sparks, or smoke having been seen. I proved, beyond dispute, that the flame of powder cannot pass through imprisoned water. The process, though absolutely safe and efficient, is somewhat complicated, and its first cost expensive. I soon perceived that a simpler process was possible, and capable of producing the same effects.

My second step, therefore, was to modify, this gun and invent an instrument which I call my patent "safety spring detonator."

Laying aside the original "mining gun," I inserted this detonator inside the explosive charge, which, after having been made water-tight, was placed in an empty hydraulic or water-cartridge, which, on being filled with water, completely surrounded the explosive with that element. This, on being placed in a properly prepared borehole and tamped, was fired by means of a wire-line, which, passing through the cork stopper of the water-cartridge, and tamping, may be carried to any safe distance from the mouth of the borehole. This simpler process also accomplished the object I had in view, namely:—the prevention of flash, flame, and smoke. But experience and closer observation led me to suspect that the process might be still further simplified.

My third step was as follows: to insert the miners' ordinary cartridge in the borehole in the ordinary way—thus interfering as little as possible with the miners' old habits and experiences— alongside a flat leaden fuse, and immediately following the explosive cartridge I placed one of my hydraulic cartridges. I may here incidentally remark that all danger from tamping is done away with, for you have from one to two feet of water between the explosive and the tamping, effectually protecting it from the dangers incidental to tamping—which admits of that final operation being done more thoroughly; but, even with less care than usual in the tamping, a "blown-out" shot becomes almost impossible, as I shall presently describe. The fuse having been ignited, in the usual manner, it was discovered that the flash or flame, and smoke were destroyed, as in the other two processes already described.

I had now reached the perfection of simplicity, and paper cartridges being inexpensive, there remains no reason why the principles should not be universally adopted. But, further than this: the effect of the shot, in combination with the water-cartridge, was observed to be so much greater

than when fired *without* the water, that it needed only a few more experiments to prove that at least *one-half* the usual quantity of powder might be saved.

The action of the water-cartridge is as follows: The column of water receives the force of the explosion, which acting instantly like a wedge, distributes the pressure on all sides over the whole length, thus catching, storing up, and distributing the force in an instant, while other beneficial effects continue to follow fast upon each other's steps: 1st, The destruction and instantaneous burning of the paper tube. 2nd. The liberated water instantly and simultaneously expands laterally, with the full force of the explosion, forming a natural and independent tamping to the gases, keeping them to their work, and reducing to a minimum the pressure on the front tamping, thus presenting an efficient check to "blown-out shots." 3rd. The water again, in the same instant, being converted partly into steam, partly into vapour, and mixing with and acting upon the nascent super-heated gases produced by the explosion, destroys the flame in its birth, and prevents its spread to the combustible gases and minute particles of carboniferous matter (coal dust) floating in the atmosphere of the mine. This, briefly, is the action of the water-cartridge in its simplest and, I admit, most important principle.

To recapitulate, we have, therefore, accomplished two things:—

First—The prevention of flash, flame, and smoke, by either of the three processes described, being the one principle which I have invented and patented.

Second—A saving of half the powder used on the old system.

But the improvements and usefulness of the invention do not stop here. By means of the water-cartridges you obtain complete control over the force generated by the explosive.

By merely varying the length and diameter of the hydraulic cartridge you can distribute that force over any practicable surface or extent you please. In "pillaring" slate rock, this will be found of the greatest importance.

The force executed by an ordinary charge of gunpowder acts only upon the small space within which it is confined; the surrounding effects of the shot radiating from that point are hap-hazard in their course and results, the weakest parts only giving way. But when this force is received by one or more water-cartridges, placed either below or above, or both, or entirely surrounding the explosive, it is as uniformly distributed as may be desired. None of the force is lost, and almost any desired effect may be obtained under all circumstances of blasting, whether in coal mines, slate-rock quarries, rock-rending, or in submarine operations. And not only in these works, but I claim to be able to effect great results in discharging heavy ordnance and torpedoes, and having further devised a new explosive cartridge more powerful and safe in its action than has hitherto been used, I think I have simplified blasting operations to the utmost.

For the rest, I have only now to invite your attention to the sundry means by which I improve the method of igniting the charge.

1. My simplest "Hand Detonator" is this which I hold in my hand. It is an instrument by means of which the miner can under all and any circumstances ignite his fuze with certainty and safety, and, I may say, comfort, in the dark, or under dripping roofs: he merely inserts the end of the fuse with his finger and thumb, into the muzzle, and by an easy and simple action the work of ignition is done with certainty. The men are well pleased with this useful instrument—I had almost said toy (for the boys all want one), and I expect in a short time, but few miners and quarrymen will be without one. It is a simple modification of my "mining gun" referred to.

2. Next, and more important, but less expensive, is the "safety spring detonator." This, being fixed in the charge, is destroyed and lost each time, but it enables you to dispense with all fuse, or naked ignition, being worked through the vent-hole and operated upon by a wire-line at a safe distance.

3. My permanent "safety-plug detonator."—This modification has a circular wedge-shaped head, and is used as follows: It also dispenses with all external ignition and sparks, being tamped in the mouth of the bore-hole, it fires a "squib," "straw," or fuse, placed in its muzzle, or a train of powder previously laid in, or afterwards inserted by means of a "pricker" behind the tamping (by which it is protected and imprisoned), running down the side of the water-cartridge to the charge below; so that, from first to last, all flame, sparks, or naked fire is kept under control, confined, and smothered.

In conclusion, I will relate a few experiences of safety and economy in blasting coal with water-cartridges. At Messrs. Nadin's Stanton Coal Pit, where I conducted my first experiments, while gas, (carburetted-hydrogen) was rushing out at the mouth of a newly-drilled hole, (4 ft. by 2 in. diameter), the miners, who had now gained confidence in my safety process, willingly remained to witness the experiment. I put a one-foot charge of powder, a two-foot hydraulic cartridge, and one foot of tamping, which was fired with the usual successful result:—no flash, flame, or smoke being visible.

In a bore-hole 4 ft. by 1½ in. diameter, was placed one foot of powder, a two-foot hydraulic cartridge, and one foot of tamping, the coal seam (the Woodfield) was "started" for 30 (thirty) feet, or 15 feet right and left of the shot. This coal sticks very fast to the shale roof, and is allowed to be the most difficult coal to get in England. Two bore holes with

their powder charges were saved, (one on either side of the blast hole.) I usually saved one, and often two holes while operating on this seam.

With these few detailed results in this pit, and combined with the other important results enumerated in my certificates from other pits and the slate-rock quarries of North Wales, I think you will allow that I have been completely successful in my experiments with hydraulic or water cartridges.

Mr. Atherton: At the invitation of Mr. Tonge, I had the pleasure of accompanying him to witness the few experiments he has described. I am disposed to think that there is something in the invention, and I think it will be well to discuss it further, and have more experiments. I was not altogether satisfied with the experiments I saw; in some instances they were uncertain. In one instance the water cartridge was evidently crushed during the tamping process, as water ran out during that process. From that and other causes I did not place much reliance on some of the shots, but there were one or two where the water was evidently called into play, and in those cases there were useful results. In one case, where I expected the shot would have been visible in the form of sparks—probably also flame to some feet from the bore-hole, the water seemed to act well. Nothing was seen except one or two faint sparks at the mouth of the bore-hole. That shot did a great deal of work. On the whole, I should think it did rather more than powder alone would have done. I am not prepared to say how this could be, but I am certainly of opinion that in one or two cases, where apparently the water did work, the result of the shot was not any less than it would have been with powder only. If anything, it was rather more. The matter is certainly one that we should know more about.

The kind of cartridge used was found to be not altogether the best. Tin was evidently too strong for the purpose, while on the other hand the paper cartridges were too light. It was suggested at the close of the experiments in question that in any further experiments it would be well to have the charge of powder enclosed within a charge of water. That Mr. Tonge has not had time to carry out, but I have no doubt if he had conducted more experiments he would have had the cartridges in that form. I should be very glad indeed to know that the subject is being carried further. As to some of the things Mr. Macnab has brought before us, I confess I do not feel quite clear; I am doubtful about his method of igniting the charge for instance. When ignition is produced by a spring and wire, I see danger from premature explosion.

Mr. Unsworth said it appeared that Mr. Tonge, in his experiments, had all the appliances that Mr. Macnab used except the detonating fuse. It appeared also that he had used tin instead of paper for the water cartridges. With those exceptions, Mr. Tonge had done all that Mr. Macnab said he ought to have done.

Mr. Macnab explained the method of firing a shot by means of the wire-line, the working of which he showed was perfectly safe. He had, he said, never known the remotest approach to an accident to occur. With regard to Mr. Tonge's having followed out his ideas, that, to a certain extent, was quite right, but the stumbling-block was the tin cartridge. This, filled with water, resolved itself into a solid incompressible body; of this, proof was given by the fact of some having been blown out with the water in them. Mr. Macnab further said, that the water, at the moment of its liberation, extinguished the flame from the shot and absorbed the carbonic acid gas. The greater the pressure of carbonic acid gas upon the water, the greater was

the absorption of that gas by the water. In his experiments they could see nothing, and all that was heard was a gentle report. The concussion of the air was reduced to a minimum.

The CHAIRMAN: This point, of the absorption of carbonic acid gas by water, is an advantage which has not been stated before to-day.

Mr. MACNAB said it was particularly mentioned in his specification.

Mr. TONGE said it should be borne in mind that his experiments were made solely with the view of testing whether the statements in the letter to the *Times* were correct or not. For a considerable time he confined his attention to that letter, but not being fully satisfied with the results, he began to think of something better, and the thing which he thought answered the purpose best was that described in the paper.

Mr. MARTIN said he thought the difficulty with regard to the compression of the cartridge might be got over by not filling it quite full with water. Then, compression would take place, and by the fracture of the cartridge the water and flame would be brought into contact. Mr. Macnab very properly said that if the tin was perfectly full, compression being equal on all sides, it became a solid body; on the other hand, if not perfectly full, there was no reason why the explosion should not burst the cartridge.

Mr. MACNAB said that Mr. Martin's observation was quite justified, at the same time his suggestion would by no means cure the evil. A quantity of air would be left in the water-cartridge which ought not to be there. Mr. Tonge, from his description, had realised the best effects from certain appliances he used; the effects he had realised, in this case, were the same that he (Mr. Macnab) had actually got from his mining-gun. Referring to Mr. Tonge's diagram, showing the mechanism of the cartridge he used, Mr.

Macnab pointed out in what respects they differed, and observed that the zinc used in the manufacture of his own water-cartridge became fused by the intense heat from the shot.

The CHAIRMAN, in closing the discussion, said it was quite clear they had got the principles of the invention before them, and a statement of the experiments which had been made brought pretty well up to the present time. He hoped some other members of the Society would take up those experiments, and with the light that had been thrown upon the subject both by the paper and discussion, some useful results might be attained.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART IV. VOL. XVI. SESSION 1880-81.

At the ORDINARY MEETING of the Members of the Society, held on Friday, the 28th day of January, in the Lecture Room, Public Hall, Wigan;

WILLIAM SMETHURST, Esq, F.G.S.,
in the Chair.

The CHAIRMAN announced that the Mayor and other local authorities requested that the meeting should be adjourned, owing to the disturbed state of the district resulting from the strike of colliers.

Mr. John Goodall, Surveyor, Birley Collieries, near Sheffield; and Mr. John Hodgekins, Colliery Manager, Downall Green Colliery, Ashton, near Wigan, were elected ordinary members; and the meeting adjourned.

The following communications being taken as read :—

IRON-MASKED ROCKS.

By G. H. KINAHAN, M.R.I.A., President of the Royal Geological Society of Ireland, &c., &c.

Some time since, in a paper read before the Society, attention was directed to the peculiarities of the rocks associated with the lode at the Parys Mines, and in the

discussion thereon it was pointed out that similar rocks occurred, associated with the lodes at the Ovoca Mines, Co. Wicklow.

In connection with these rocks in South East Ireland, there seems to me to be points of interest which may be of interest to others also; but previous to mentioning them, it is necessary to enter into a few details.

The Lower or Cambro-Silurian Rocks of South East Ireland, as I have previously mentioned elsewhere, were subjected to two classes of Metamorphism:—Regional or Metapeptic action, which extends over large areas, irrespective of the protrusions of the granite and other eruptive rocks; and Local or Paroptetic action ("Contact metamorphism" of Delesse), the metamorphism confined to restricted limits, adjoining protrusion of eruptive rocks or vents of heated water, gases, or a mixture of both.

The rocks affected by Metapepsis are outside the limits of the present inquiry; to those, therefore, due to Paroptesis we will direct attention. The latter rocks have distinct characters. If the protrusions are basic elvans, which may be classed under the general name of Granitone, the rocks are "baked," being changed into granulyte, leptinyte, &c.; but if the protrusions are silicious granitic rocks (granites and elvans), the action causes a development of the foliation in the metapeptic rocks; argillytes and the allied submetamorphic rocks being changed into typical schists, while in most cases they become *Iron-masked*, to use the term of the Australian geologist,—that is, they become so impregnated with iron as when weathered to be quite iron-stained; having an appearance as if they had been burnt, which has given rise to the Co. Wicklow name—of *Burnt Rocks*.

Although these "Iron-masked" rocks are adjuncts of many of the protrusions of the Leinster granitic rocks, they are not, however, always present—as apparently—they are only associates of the newer granites. The age of the latter granites has not been satisfactorily proved; it is evident they are newer than all the rocks in the area except those of Carboniferous age; but whether they are older or younger than the Silurian is uncertain, because in S.E. Ireland no rocks between the Cambro-Silurian and Carboniferous are represented. I would, however, suggest that it is possible, if not probable, they belong to the vulcanicity of the Glengariff Grit time, that is of the "Passage beds," between the Silurian and the Carboniferous;—because elsewhere in Ireland (Cork, Galway, Mayo, Roscommon, Fermanagh, Tyrone, &c.,) we find products of such an action.

"Iron-masked" rocks are also associated with the mineral courses or lodes at Ovoca. This would possibly suggest that there may be a connection between the protrusion of these newer granite rocks and the formation of these lodes. If the iron-masking was an independent process, it might be expected to be met with in all similar beds of rock; this however is not the case as apparently it is confined to certain limits and those are,—the vicinity of these newer granites and the vicinity of these mineral courses—at the same time it must be allowed; that apparently, all rocks adjoining to these granite protrusions are "iron-masked," while it is only the felspathic rocks associated with the mineral courses which are similarly affected; for in the western portion of the Ovoca Mineral course, the "Country rocks" are hornblendic and such like rocks, that do not appear to be "iron-masked"; this, however, cannot be positively stated, as the old workings hereabouts are at present in such a condition that no satis-

factory examination can be made of the mineral veins or the associated rocks.

The "iron-masked rocks" of the country generally are more or less calcareous rocks, in some of which the iron would seem to have been originally chalybite *; but in others it occurs as a pyrite or they may be ferriferous-leptinyte,—argillaceous rocks now changed by Paroptetic actions; or felspathic rocks that seem to be intrusive. From the small unsatisfactory surface exposures it is often nearly impossible to say if a felspathic rock is intrusive or metamorphic. Appearances in many cases would suggest that they were of metamorphic origin, yet some of them, as those at Madam Butler's lode, Cronebane, when they are examined both in the drivings and sinkings are found to be undoubtedly intrusive.

In connection with the "burnt" or "iron-masked" rocks, which extend obliquely across S.E. Leinster, there are, on the hill-slopes and in the adjoining low boggy valleys, accumulations, locally known as *Black heaps*. These heaps have been observed to occur in places from the east coast of Wicklow, across Wexford, and into Waterford, nearly to Dungarvan—in some localities being much more numerous than others. In a few places a field, in which such a heap occurs, is called the "Kiln-field," but why, no one can tell; and there seems to be no local tradition to give a clue to their origin; but that they were connected with some primitive metallurgical process seems to be suggested both by their positions and composition.

* See poor iron ores mentioned in the paper "On the Rocks of the Ballymoney Series, Co. Wexford." Transactions of the Manchester Geological Society, Vol. XIV., page 145.

A "black heap" is from 10 to 30 or even 50 yards in diameter; their original heights it is impossible to tell, as they are all tumbled down, and often more or less carted away. They consist for the most part (about two-thirds) of a black, friable, earthy per-oxide of iron and manganese, somewhat like "black-bog-iron-ore," in which are mixed up angular fragments of burnt or roasted stones, that were broken to a size of from 1·5 to 2 inches across. In most of the heaps these fragments seem, originally, to have been one of the felspathic varieties of "iron-masked rocks"; but not always, as in some heaps there is more or less slag, as if one of the limey varieties of the rock had been used.

As a general rule, in the ground adjoining the heaps, all traces of ancient mining operations are now obliterated, or so obscure as to be unrecognizable; but not always, for on the hill to the northward of the "Kiln-field," Knocknamo-hill, near Ovoca, there are old mine holes; while near Redcross, south-west of the ancient Ballycapple iron mines, there were very large "black heaps," that a few years ago were carted to Wicklow and shipped to England, to be utilized in the purification of gas. Near the centre of the base of these heaps were found fire-places of bricks, about 3 feet square and a foot and a half high.

To these "black heaps" I would ask attention, as they are a mystery to me. From the rock fragments in them, it would appear that the stone generally roasted were pyritous felspathic rocks; of which there now remains in the heaps, the iron and the stone matrix. This may, perhaps, suggest that the process was for obtaining sulphur, as, in general, in these rocks there is only a trace of copper; but if it was the sulphur that was required; how was it obtained? what use was made of it? and who were the metallurgists?

RAIN FALL FOR 1880, ON THE SOUTH-EASTERN BOUNDARY OF LANCASHIRE.

Contributed by WILLIAM WATTS, F.G.S.

Height of Guage above Sea-level.	766-ft.			965-ft.			950-ft.			800-ft.		
	PIETHORNE.			DENSHAW.			BRUSHES.			STRINESDALE.		
	Rainfall.	Wet Days.	Fine Days.	Rainfall.	Wet Days.	Fine Days.	Rainfall.	Wet Days.	Fine Days.	Rainfall.	Wet Days.	Fine Days.
	Ins.			Ins.			Ins.			Ins.		
January	0·54	8	23	0·50	5	26	0·65	8	23	0·46	6	25
February	2·73	22	7	3·41	23	6	3·29	24	5	1·76	25	4
March	3·16	10	21	3·96	10	21	3·94	11	20	2·65	9	22
April	2·12	20	10	2·40	18	12	3·21	18	12	2·99	16	14
May	2·32	9	22	2·71	11	20	2·73	11	20	2·63	14	17
June	2·25	17	13	2·89	21	9	2·48	20	10	2·20	19	11
July	6·42	23	8	7·10	23	8	7·16	25	6	5·91	25	6
August	1·83	6	25	2·04	5	25	2·45	8	23	2·07	6	25
September	4·35	17	13	5·29	17	13	5·46	18	12	4·95	17	13
October	1·56	17	14	5·93	15	16	5·65	16	15	4·71	16	15
November	4·27	18	12	4·03	18	12	5·05	17	13	3·26	16	14
December	5·66	25	6	6·07	24	7	7·28	20	11	5·90	25	6
	37·21	192	174	46·33	191	175	49·35	196	170	39·49	194	172

Diameter of Rain Gauge funnel 5 ins: at all the Stations.

WILLIAM WATTS, MANAGER of the Oldham Corporation Water Works.

SECTIONS OF COLLIERIES AND BORE-HOLES,

IN THE MIDLAND COAL FIELD.

Likely to be of interest to the Members.

CONTRIBUTED BY

JOHN THOMAS BOOT, C. & M. E.

ANNESLEY COLLIERY, NEAR NOTTINGHAM.

No.	Name of Strata.	Thickness of Seam. Yds.	Ft.	In.		Depth from Surface. Yds.	Ft.	In.
1.	Sand and Gravel	2	0	0	....	....		
2.	Do. Rock	26	0	0	....	....		
3.	Permian Marls	8	0	0	....	....		
4.	Magnesian Limestone	6	2	2	....	....		
5.	Lower New Red Sandstone	1	1	1	....	....		
6.	Cudworth Seam of Coal	0	1	2	....	107	1	2
7.	Clown do.	1	1	0½	....	229	1	2
8.	Tinsley Park do.	1	0	0	....	367	0	0
9.	Hucknall Common	0	2	5	....	416	1	0
10.	Combe Coal	0	1	2	....	476	1	2
11.	Top Hard Coal	1	1	0				
	Total depth of pit	....			....	504	1	0

THE BOLSOVER COAL FIELD.

No.	Name of Strata.	Thickness of Seam. Yds.	Ft.	In.		Depth from Surface. Yds.	Ft.	In.
1.	Shuttlewood Coal	1	1	3	....	132	0	0
2.	Clown do.	1	1	0	....	159	0	0
3.	Tinsley Park do.	0	2	6	....	199	0	0
4.	Swallownest do.	1	1	0	....	247	0	0
5.	Two Feet do.	0	2	0	....	302	0	0
6.	Yard do.	1	0	0	....	313	0	0
7.	Top Hard do.	2	0	0	....	389	0	0
8.	Dunsill do.	1	0	0	....	417	0	0
9.	Chavey do.	1	0	0	....	510	0	0
10.	Main Soft do.	1	2	0	....	525	0	0
11.	Deep Hard do.	1	2	6	....	554	0	0
12.	Three Bedded do.	0	2	0	....	577	0	0
13.	Yard do.	1	1	0	....	675	0	0
14.	Blackshale do.	1	1	0	....	678	0	0

BROXTOW WOOD PIT, CINDER HILL COLLIERIES,

Near Nottingham.

No.	Name of Strata.	Thickness of Seam. Yds.	Ft.	In.	Depth from Surface. Yds.	Ft.	In.
1.	Coal	1	0	0	9	0	7
2.	Do.	0	1	6	11	1	7
3.	Do.	0	0	1	12	2	2
4.	Do.	0	1	5	24	2	0
5.	Do.	0	1	6	33	2	1
6.	Do.	1	0	0	57	0	0
7.	Combe Coal	0	1	2	97	0	6
8.	Top Hard Coal	2	0	4½	98	1	8
9.	Dunsill Do.	1	0	0	126	1	2
10.	Coal	0	1	2	137	2	5
11.	Do.	0	0	11	141	1	4
12.	Waterloo Coal	0	1	9	158	0	0
13.	Coal	0	2	6	175	0	2
14.	Do.	0	1	2	179	1	3
15.	Do.	0	1	10	192	0	5
16.	Ell Coal	0	0	5	228	0	4
17.	Coal	0	1	0	236	0	0
18.	Deep Soft Coal	0	2	6	246	0	7
19.	Deep Hard do.	0	2	2	256	0	6

CHILWELL BORE HOLE,

About Four Miles South-West of Nottingham.

No.	Name of Strata.	Thickness of Seam. Yds.	Ft.	In.	Depth from Surface. Yds.	Ft.	In.
1.	Keuper Sandstone	....		....	60	1	0
2.	Bunter	....		....	137	2	0
3.	Lower Bunter	....		....	154	2	0
4.	Thin Coal	0	0	6	171	2	1
5.	Do.	0	1	3½	186	2	0
6.	Do.	0	1	1	204	2	10
7.	Do.	0	0	9	242	0	7
8.	Do.	0	0	3	270	0	10
9.	Total length bored			....	*336	0	0

N.B.—About a mile east of this Bore Hole, nearer Nottingham, we found by boring a coal which is supposed to be the Deep Soft Seam, at 178 yards deep from the surface, and 4 ft. thick, and at 203 yards from the surface we found which is supposed to be the Deep Hard Seam, 4 ft. 3 in. thick. These two borings appear rather conflicting.

* Left off in Coal Measures.

CLIFTON BORE HOLE,

South of the River Trent.

No.	Name of Strata.	Thickness of Seam. Yds.	Ft.	In.		Depth from Surface. Yds.	Ft.	In.
1.	Keuper Sandstone	....			....	86	2	3
2.	Bunter do.	....			....	153	1	6
3.	Lower Bunter do.	....			....	174	0	0
4.	Coal Measures (Bend, Ironstone, &c.)	....			....	185	0	5
5.	The Combe Coal, and Top Hard Coal, with 2 in. parting between	1	2	7½	....	187	0	0

N.B.—These borings were made on the South or "Dip" side of the Trent Valley Fault. See sinkings on the East or "Rise" side of the said fault.

CLIFTON SINKINGS AT NOTTINGHAM,

On the East or Rise Side of the Trent Valley Fault.

No.	Name of Strata.	Thickness of Seam. Yds.	Ft.	In.		Depth from Surface. Yds.	Ft.	In.
1.	Soil	0	0	10	....	....		
2.	Gravel	8	0	0	....	....		
3.	Grey Sandstone	17	0	9	....	....		
4.	Red do.	9	1	7	....	....		
5.	Red Sandstone and Marls	16	2	9	....	....		
6.	Conglomerate	0	0	11	....	....		
7.	Commencement of Coal Measures: Combe Coal	0	2	8	....	60	0	0
8.	Top Hard Coal	1	2	11½	....	*69	0	0
9.	Dunsill do.	1	0	0	....	94	0	5
10.	Waterloo do.	1	0	3	....	104	0	8
11.	Thin do.	0	1	10½	....	†113	2	6½
12.	Do. do.	0	1	10	....	175	1	3
13.	Deep Soft do.	1	2	0	....	239	1	0
14.	Deep Hard do.	1	2	7½	....	252	1	5½
15.	The Piper do.	1	0	4	....	267	2	0

* Very inferior seam. † Good quality.

HUCKNALL TORKARD SINKINGS, NEAR NOTTINGHAM.

No.	Name of Strata.	Thickness of Seam. Yds.	Ft.	In.		Depth from Surface. Yds.	Ft.	In.
1.	Cudworth Seam of Coal	0	2	2	....	43	2	4
2.	Thin Coal	0	2	0	....	71	2	1
3.	New Hill Seam of Coal	0	1	9	....	142	1	3
4.	Clown do.	1	1	5	....	188	1	6
5.	Patterton do.	0	1	5	....	199	1	6
6.	Sough do.	0	0	8	....	233	1	6
7.	Tinsley Park do.	1	0	1	....	297	2	0
8.	Hucknall Common	0	2	4	....	342	1	0
9.	Thin Coal	0	0	7	....	367	1	0
10.	Do.	0	1	4	....	390	0	0
11.	Combe Coal and the Top Hard Coal	2	0	1	....	413	0	10½

N.B.—The names given to these seams are in part taken from the Yorkshire Coal Field.

PLEASLEY COLLIERY, NEAR MANSFIELD.

No.	Name of Strata.	Thickness of Seam. Yds.	Ft.	In.		Depth from Surface. Yds.	Ft.	In.
1.	Brown Limestone	....			....	21	0	0
2.	Hard Blue do.	....			....	31	0	0
3.	Blue Soft do.	....			....	43	2	5
4.	Dark Brown do.	....			....	50	0	5
5.	Brown Mingled Limestone	....			....	50	1	5
6.	Brown Hard do.	....			....	60	0	0
7.	Limestone and Rock	....			....	*82	1	3
8.	Coal Smutt	0	0	1½	....	101	0	0½
9.	Grey Sandy Rock	....			....	†116	1	1
10.	Coal	0	1	2	....	140	0	7½
11.	Bind, with Rock	....			....	‡145	1	7½
12.	Coal	0	2	0½	....	150	0	4
13.	Do.	0	0	6	....	152	1	1½
14.	Do.	0	0	8	....	154	1	4½
15.	Do.	0	0	8	....	170	2	6
16.	Do.	0	0	3½	....	181	1	10½
17.	Do.	0	0	11	....	190	1	11½
18.	Do.	0	2	0	....	191	1	11½
19.	Do.	0	0	6	....	192	0	4½
20.	Do.	0	0	6	....	217	0	5½
21.	Do.	0	0	5	....	247	0	9½
22.	Do.	0	0	3	....	278	0	9
23.	Top Hard Coal	1	2	6	....	514	1	6½
	Total depth of Sinkings	....			....	523	1	0

* With large quantity of water. † With water 1200 galls. per minute. ‡ Bottom of tubbing.

CORRECTED SECTION OF STRATA FOUND AT THE SCARLE BORE HOLE, NEAR LINCOLN.*

	Ft.	In.	
Alluvia or Drift	10	0	Alluvium.
Lower Lias Clay and Limestone	65	0	Lias.
Rhatic Beds	66	0	
New Red Marl	573	0	Keuper.
Lower Keuper Sandstone	244	0	
New Red Sandstone	543	0	Bunter.
Upper Permian Marls	118	6	Permian.
Upper Magnesian Limestone	40	6	
Middle Permian Marls	141	0	
Lower Magnesian Limestone	26	0	
Marl Slates	193	0	
Upper Coal Measures	13	0	Carboniferous.
Total	2033	0	

The following Temperatures were obtained, the bore-hole having remained undisturbed for five weeks before the observations were taken :—

Date. 1876.	Depth. Ft.	Temp. Fahr. Deg.	Time Down. H.	M.	Date. 1876.	Depth. Ft.	Temp. Fahr. Deg.	Time Down. H.	M.
June 15th	100	68	1	0	June 16th	1000	69⅛	0	35
,,	200	68½	0	30	,,	1100	69⅛	0	35
,,	300	68¾	0	30	,,	1200	69½	0	30
,,	400	68¾	0	30	,,	1300	70⅛	0	35
,,	500	68¾	0	30	June 17th	1400	71	0	35
,,	600	69	0	30	,,	1500	73	0	40
,,	800	69	0	30	,,	1950	78	1	15
,,	900	69	0	30	,,	2000	79	2	0

The instrument employed was the "Protected Negretta Maximum Thermometer."

At 790 feet deep, in fine grained sandstone, and at 945 feet to 950 feet, in hard white freestone, powerful springs of water found, which spouted up 4 to 6 in. above the surface.

* This hole was bored by the Diamond Rock Boring Machine, in the years 1873, 1874, 1875, and 1876, and is situated about 65 chains south of South Scarle Church, and about six miles S.W. of Lincoln, between Collingham and Swinderly Station, on the Newark and Lincoln line of the Midland Railway.

SHIREOAKS COLLIERY.

No.	Name of Strata.	Thickness of Seam. Yds.	Ft.	In.		Depth from Surface. Yds.	Ft.	In.
1.	Shafton Coal	0	2	0	....	87	0	5
2.	Strong Blue Bind	4	0	5	....	91	0	10
3.	Rotherham Thick Rock	66	1	5	....	158	1	5
4.	Coal	0	1	4	....	158	1	5
5.	Ditto	0	1	4	....	175	1	3
6.	Ditto	0	0	8	....	182	0	0
7.	Ditto	0	2	10	....	181	0	2
8.	Ditto	0	0	9	....	189	1	9
9.	Ditto	0	0	5	....	190	1	4
10.	Ditto	0	0	11	....	208	2	9
11.	Ditto	0	1	2½	....	229	0	4
12.	Ditto	0	0	4	....	234	1	8
13.	Ditto	0	1	2	....	*321	2	0
14.	Clown Coal	1	2	3	....	345	2	3
15.	Coal	1	0	2	....	365	0	6
16.	Ditto	0	2	8	....	386	2	6
17.	Ditto	0	2	1	....	410	2	2
18.	Ditto	0	2	7	....	434	1	10
19.	Ditto	0	1	4	....	465	0	0
20.	Ditto	0	0	7	....	508	2	3
21.	Top Hard Coal	1	0	10	....	515	0	8

ROTHERHAM THICK ROCK.

In this rock at 3½ yards deep, 1800 gallons of water per hour.
Ditto „ 9½ „ 1250 „ „ „
Ditto „ 13½ „ 1400 „ „ „
Ditto „ 25 „ 5000 „ „ „
Ditto „ 53 „ 6400 „ „ „

* Supposed to be the New Hill Coal.

TEVERSALL COLLIERY, near Mansfield.

"Rise side of the main fault."

No.	Name of Strata.	Thickness of Seam. Yds.	Ft.	In.		Depth from Surface. Yds.	Ft.	In.
1.	Top Hard Coal	1	2	6	....	51	1	5
2.	Dunsill do.	1	1	0	....	72	1	4
3.	Waterloo do.	0	2	7	....	109	0	0
4.	Thin do.	0	2	4	....	132	0	8
5.	Ell do.	0	1	4	....	141	2	9
6.	Deep Soft do.	0	0	2	....	275	0	0
7.	Deep Hard do.	0	2	7	....	290	1	2
8.	Furnace do.	1	2	2½	....	356	1	5½
9.	Three-quarter Coal	0	2	6	....	362	1	6
10.	Coal	1	0	4	....	396	0	1
11.	Blackshale Coal	1	0	2	....	418	0	0

TIBSHELF COLLIERY, near Alfreton.

No.	Name of Strata.	Thickness of Seam. Yds.	Ft.	In.		Depth from Surface. Yds.	Ft.	In
1.	Coal	0	0	2	....	6	0	7
2.	Do.	0	0	2	....	18	0	4
3.	Top Hard Coal	1	1	0	....	35	0	7
4.	Coal	0	1	3	....	44	0	2
5.	Dunsill	0	2	4	....	58	1	2
6.	Coal	0	0	9	....	67	0	0
7.	Waterloo Coal	0	2	9	....	94	0	3
8.	Deep Soft do.	0	0	9	....	262	0	0
9.	Deep Hard do.	0	3	4	....	268	2	5
10.	Tupton do.	1	2	5	....	331	1	8
11.	Three-quarter Coal	0	2	6	....	337	0	2
12.	Yard do.	0	2	3	....	365	0	0
13.	Blackshale do.	0	3	7	....	386	0	5

LANGWITH NEW COLLIERY,

NEAR BOLSOVER.

No.	Name of Strata.	Thickness of Seam. Yds.	Ft.	In.		Depth from Surface. Yds.	Ft.	In.
	Soil	0	1	0	....	....		
	Magnesian Limestone	29	2	8	....	....		
1.	Coal	0	0	8	....	90	0	4
2.	Do.	0	0	3	....	95	0	1
3.	Do.	0	0	1	....	101	2	1
4.	Do.	0	1	0	....	117	1	5
5.	Do.	0	0	2	....	126	1	4
6.	Do.	0	1	9	....	132	2	11
7.	Do.	0	1	6	....	142	2	7
8.	Do.	0	0	1	....	146	1	9
9.	Do.	0	0	7	....	165	2	3
10.	Do.	1	0	2	....	190	0	0
11.	Do. Very inferior	0	0	7	....	255	0	3
12.	Do.	1	0	6	....	272	2	0
13.	Do.	0	0	8	....	274	1	6
	Black Bind full of small Cockle Shells	4	2	5	....	304	0	4
14.	Coal	1	0	4	....	305	0	8
15.	Do. And Bat	0	1	5	....	317	0	5
16.	Clown Coal (good 2ft. 7in.; inferior 2ft. 3in.)	1	1	10	....	336	0	8
17.	Coal	0	1	10	....	347	0	9
18.	Do.	0	1	0	....	348	1	0
19.	Do. Inferior	0	1	0	....	357	0	0
20.	Do.	0	0	2	....	366	2	10
21.	Do.	0	0	2	....	368	0	7
22.	Coal	0	0	1	....	396	0	10
23.	Clunch, with Grey Rock, with Fossils.. Coal and Bat, 2 in.	0	1	4	....	406	2	9
24.	High Hazel Coal	1	0	8	....	422	2	8
25.	Coal	0	0	5	....	423	1	4
26.	Do.	0	0	2	....	425	0	2
27.	Do. and Bat	0	2	4	....	444	2	0
28.	Do.	0	1	5	....	451	0	8
29.	Do. and Bat	0	1	0	....	463	2	6
30.	Do.	0	0	6	....	502	1	4
31.	Do.	0	0	6	....	516	1	6
32.	Top Hard Coal	1	2	10	....	539	0	8
	Total Depth sunk					550	1	6

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART V. VOL. XVI. SESSION 1880-81.

At the ORDINARY MEETING of the Members of the Society, held on Friday, the 25th day of February, in the Council Chamber, Municipal Buildings, Wigan;

GEORGE GILROY, Esq., M.Inst.C.E., Vice-President, in the Chair.

The CHAIRMAN said: I may say for myself, and I think for all the members in this immediate district, that we hail with very great satisfaction the holding of meetings of the Manchester Geological Society in Wigan. We hope that they will frequently be held here in the future.

Mr. Alfred Taylor, Norley Colliery, near Wigan, was elected an ordinary member of the Society.

The Hon. Secretary announced that the following additions to the Library have been received:—

Vol. VIII. Transactions of the American Institute of Mining Engineers—*From the Institute.* Report of Geological Survey of Canada, for 1878-79—*From the Director of the Geological Survey.* U.S. G. & G. Survey of the Rocky Mountain Region: Report on the High Plateaus of Utah—*From Dr. Hayden.* Journal of the Iron and Steel Institute; No. 2, 1880—*From the Council.* Geological and Natural History Survey of Minnesota;

8th Annual Report, for the year 1879—*From Prof. N. H. Winchell*, Pamphlets from 7th Report—*From Hon. Verplanck Colvin*, Superintendent of the N.Y. State Adirondack Survey. Journal of the Royal Geological Society, Dublin; Vol. V. (New Series), Part 3—*From the Society*. Transactions of the Mining Institute of Scotland; Parts 8 and 9, Vol. II.—*From the Council*. Proceedings of the Royal Institution of Great Britain; Vol. IX., Part iii., No. 72—*From the Council*. Geologists' Association, London: Proceedings; Parts 8 and 9, Vol. VI.—*From the Council*. Proceedings of the S. Wales Inst. of Engineers; Part 3, Vol. XII.—*From the Institute*. Proceedings of the Mechanical Engineers; No. 4, 1880—*From the Council*. Transactions of the N. of England Institute, M. and M. Engineers; Part 1, Vol. XXX.—*From the Council*. Bulletin Société Vaudoise des Sciences Naturelles; No. 84, Vol. XVII.—*From the Society*. Zeitschrift der Deutschen Geologischen Gesellschaft; Heft III, Band XXXII.—*From the Society*. Pamphlets (Papers by G. H. Kinahan, M.R.I.A., read before the Royal Irish Academy)—*From the Author*. Quarterly Report (ending 30th Sept., 1880,) of the Mining Surveyors and Registrars, Victoria.

THE LONG WALL SYSTEM OF WORKING COAL.

By Messrs. Grimshaw and Phillips.

(See Parts XIV., XV., and XVI., Vol. XV.)

Mr. Hedley said: I think in discussing this question generally, that it will be desirable to consider the position and prospects of the long wall system in this district. For some time it has been becoming more in vogue at different collieries, and with a certain amount of success, and I am convinced that a paper of the kind that Messrs. Grimshaw and Phillips have brought before us will be very useful in calling attention to the matter, and will therefore do a great deal of good. It is what we have wanted in the district for some time. In the Midland Counties, which may be called the home of the long wall system, the seams have been

worked to perfection and with little difficulty for a considerable time past. In this district on the other hand, there has been considerable difficulty in working the seams in that manner. Now, the question arises whether that is due to the nature of the seams themselves, or whether it is due, I will not say to the ignorance but to the want of knowledge of the details of that manner of working. In my opinion there are several reasons why we cannot work these seams on the long wall system as well as those in the Midland Counties. First of all, this is a faulty district. Then again we suffer from the want of experience on the part of the men. Generally speaking we have a very good idea of what should be done, but we are not well up in the details, and on the details of the working depends, I have no hesitation in saying, the success of the system. I am not now speaking on mere theory, but from what I have myself seen. It is well-known that to work coal on the long wall system to the best advantage, you must work the face with regularity, and this can be better done in the Midlands, where six, eight, or even ten men are employed in one working place, than in this district where two men only are employed, and who work perhaps for four or five days a week only, where as in the former case, some of the men are sure to be at work daily. I do not hesitate to say that if in this district we adopted the long wall system more generally, we should not only do with less timber, but it would be better for the roof, safer for the miners, and it would give a larger percentage of round coal. I see that Messrs. Grimshaw and Phillips in their paper, page 318, referring to the opening work developed by means of a leading stall, and the opening out of faces at certain intervals, say that you get the face opened out in a series of steps. The question of

opening out in a straight face or in steps depends a great deal upon the nature of the seam itself. Some seams you can work with a straight face; other seams from various causes you can only work in steps. But if it is necessary to work it in a straight face there is no difficulty whatever in the matter. In opening out it is simply a question of working more at one end of the stall than the other. By that means you always have the face in one straight line with the exception perhaps of the last stretch. Many people object to the long wall system because they say you cannot ventilate the roads, which therefore get foul. But there is no difficulty about that if the wind is taken in the right direction, that is by the main roads and allowed to circulate up the face of the workings, for in that manner you get a scale of air at each gateway, which works its way through to the return air. The great point to which attention ought to be paid in this district is educating the men themselves in the details of working the long wall system. You very seldom see in this district men hole the whole length of the place. They hole about a couple of yards and then get that down, leaving a corner of the face to stand all day, the result being that in the morning that coal is crushed. Then again instead of the men engaged in getting coal doing the packing themselves special men are sent in as packers. The packs are not put in as required, or as soon as there is room, but the place is left until there is a good day's work, standing on the timber, the result being, that as there is no pack for the roof to settle upon, the roof is broken, the timber smashed and destroyed, and the weight is thrown over on to the face, crushing the coal. I am very glad to see that the long wall system is becoming more general in this district, but I

think before we can make it a success we must pay more attention to details. Till that is done we cannot expect to do as well as in the Midland Counties, where the system is worked so successfully.

Mr. W. J. Grimshaw: It must not be forgotten that in the Midlands generally very different conditions prevail to those which prevail in Lancashire. We have to leave for buildings, and have not the same chance of packing a long face as there is in the majority of cases in the Midland counties. That is one drawback to the long wall working here, and it is a very great drawback too. Even in the midlands different systems prevail in different mines, things being done for the best so far as can be seen. But first of all there is a smaller quantity of straight work in proportion to the amount of coal gotten than here. Of course circumstances alter cases. In the midlands, however, the men know their work, and are set to the same work day after day, becoming skilled in that work. I am convinced that packing is better and safer than timber, and less expensive, as the timber, or a large proportion of it, is lost under the other systems. In the midland counties they have two or three rows of props set behind and a set of chocks next to the face. By the long wall system more round coal can be obtained with less trouble and expense than by pillar and stall in the same district. There are not as many roads to keep open for ventilation, and after a while the roof settles so that it will stand for a long time.

Mr. J. Longbotham: I think it has generally been considered that as between long wall faces and bord and pillar that the danger attending shot firing is somewhat greater in the long wall than in the first working of bord and pillar, because the shots point to the goaf. A short time ago

there was an arbitration in the county of Durham, in which Mr. Jacob Higson was an arbitrator. At that arbitration Mr. Bell raised the question as to whether it was safe to fire shots, and the umpire decided that inasmuch as the shots pointed to the goaf it was not a safe practice to fire shots there, at the same time, and in the very same colliery, I believe, in the pillar and stall they were then firing shots and no question was raised as to its safety. It does not follow because there has been a dearth of explosions in a particular district where the long wall system prevails that it is because that system has been adopted that so few explosions have taken place. It might for the same reason be said that as during the period between 1868 and 1880 there was a dearth of explosions in the county of Durham that such dearth was to be attributed to the bord and pillar system, which is generally adopted there. A better test would be applied if figures were given showing the accidents which are the results of falls of the roof and sides, and inasmuch as Mr. Evans's report was quoted I thought it not undesirable just to look into his figures which show the fatalities arising from falls of the roof and sides in that district for the purpose of comparing them with others. I find that from falls of the roof and sides 87 lives were lost during the years 1877, 1878, 1879, and in the same period 40 millions of tons of coal were raised, which is equal to 464,000 tons per man lost. In Durham for the same period there have been 103 lives lost, which is equal to 537,000 tons raised for each man lost, and in Northumberland during the years 1878 and 1879 there were 492,000 tons of coal raised per life lost.

Mr. Grimshaw: You must take all the losses of life and put them together. If the number of lives lost by falls of

the roof and sides in the Midland district be taken, the number of lives lost in the same manner in this district, also the number of lives lost by explosions in this district and in the midland district for the same period should be taken.

Mr. LONGBOTHAM: On page 345 in the transactions I see that the first item of cost in the example given is stated to be 2·4d. per ton. I take this to be an error, and find, on checking the addition, that it should read 2s. 4d. per ton. The total cost is put down as being 3s. 9·31d. One of the items there named is stores, and this is put down as costing 2d. per ton. I should like to ask Messrs. Grimshaw and Phillips what this item "stores" covers, and whether or not it covers all materials other than horse provender, which is the only other material item charged.

The CHAIRMAN: You will find that in the 3s. 9·31d. horses are included.

Mr. LONGBOTHAM: Does the item "stores" include all materials other than horse keeping? In Messrs. Grimshaw and Phillips' paper, stores, I see, are put down at 2d., and the only other items are horse keeping and rents. I think a very fair approximate general comparison of the cost of working in the several districts, without going into detail figures, might be obtained by ascertaining the number of tons raised in each district, and the number of persons engaged in their production.

I was somewhat curious, and, with the limited time at my disposal, I in part made this comparison, and arrived at the following figures for the year 1879:—

Inspector's District.	Tons of Coal Raised.	Persons Employed.	Equal Tons raised per Person Employed.
Mr. Evans ..	14,036,242	50,000	281
Mr. Willis ..	12,913,851	45,394	285
Mr. Bell	17,155,383	49,556	346
Mr. Hall	11,875,810	39,458	301

The above four examples show that in Mr. Evans' district the work performed per man employed is less than in any of the other three, and that, as between Mr. Evans' district and Mr. Hall's district, the latter produces 20 tons more coals per man employed, per annum, than the former, and yet I am sure there is no one in Mr. Hall's district disposed to say that coals can be worked at anything like so low a cost as 3s. 9·31d. per ton.

Mr. HEDLEY: I did not wish to be understood as saying that the long wall system can be worked in every mine in this district. I was referring more particularly to the improvements in the working of that system which might be made.

The CHAIRMAN: The question of how far the long wall system can be carried out consistent with shot firing is an important one.

Mr. HEDLEY: I think that is an argument in favour of the long wall method, for where it is properly worked firing can be dispensed with. In this district wherever the long wall system is adopted there is very little shot firing, and the work can be done in such a way that a great advantage may be obtained from the roof. With reference to

explosions, I do not agree that the long wall system is a preventative altogether. In Derbyshire there are not many lives lost from that cause, but they have a large proportion, as compared with the fiery districts, of non-fatal explosions, and the last explosions which occurred in South Wales, namely, at Pen-y-craig, Risca, and Abercarne, were in long wall collieries. Of course, I am not prepared to say what was the condition of those collieries at the time of the accidents.

Mr. J. Tonge: The colliery with which I am connected was worked during the first eighteen years of my acquaintance with it, and during all previous working, entirely on the pillar and stall system. But about ten years ago, when about to open out the Arley mine, we were invited to see the long wall system worked at some of the Hindley collieries. We were so satisfied with our visits, and with the results which we were informed were obtained by the system, that we determined to try it in our Arley mine. Though labouring under the disadvantage of managers and men being unacquainted with the new system, we obtained very satisfactory results. Starting with a forty yards face, we have gradually extended until we have got a face of 300 yards, finding room for fifty men. The roof of our Arley mine is such that, by the system of chocking we adopt, the roof cuts up—as one of our managers expresses it—like cutting butter with a knife, thus easing the face of its weight, rendering the roof comparatively secure, and giving the coal a much better chance of yielding a large amount of round. We have also been enabled by this system to do away with blasting in the Arley mine. Our success with the system in the Arley mine has been so complete that we have made a beginning with the same system in the Trencherbone or Wigan six-feet

mine, which with us is five feet six inches thick. Though told by various persons, who say they have tried it, that the Trencherbone cannot be worked by the long wall system, we have so far found it to work well. We have a far larger proportion of round coal in the first place. Whilst getting only 45 per cent. of round in a certain part of the pit by the pillar and stall system, we are getting 66 per cent. by the long wall in the same seam. The cost of working is not greater, but, if anything, slightly less. I should like to hear some of those present say what is the thinnest mine worked on this principle.

Mr. HEDLEY: Twelve inches, I think.

Mr. KENNEDY: So far as the thickness is concerned I have seen it worked from 2ft. to 6ft. The latter was the Wigan 6ft. seam, and I think there is no system either in the Midlands or in any other county that will surpass it either in the proportion of round or in the quantity of timber used. I am credibly informed that they get 90 per cent. of round coal, and that the cost of timber is not more than a farthing per ton. The Colliery is in the Wigan District. As regards the packing, it is kept as near the face as they can get it, I travelled three hundred yards and did not see one prop. So far as shot firing is concerned they have abolished it. I have never seen in the Wigan district any place where they got the same proportion of round coal.

Mr. GRIMSHAW: What proportion of slack do they leave down?

Mr. KENNEDY: None! They send all up. At the Colliery with which I am connected the packing system is adopted, and it is kept as near the face as possible. There is no comparison between the roof of our Arley Mine and that of the Six Feet Mine to which I referred, and no system in the world could

keep the roof in as good a condition. The Arley roof is much more dangerous. Upon the nature of the roof must depend in a great measure the quantity of timber required, but it is better to have packing, though sometimes it may cost a little more. It is better for the working faces. The weight is more uniform, and there is a greater probability of obtaining a larger proportion of round. But there are two things always necessary to work the long wall system with advantage. A good roof and sufficient packing. I should not think there is as much danger in firing in long wall work as in pillar and stall, and where the long wall method is adopted firing is the exception and not the rule. If some suggestions could be thrown out by which we could improve the system in this district, I have no doubt but that the managers present would gladly adopt them. I have seen a thousand yards opened nearly straight. It is packed up as well as possible. Two rows of timber have to be kept in their place, one left near the face and the other in the goaf until nearly ready for building up.

The CHAIRMAN: Where do they get the packing from for the 6 ft. coal?

Mr. KENNEDY: They hole in the dirt underneath the coal.

The CHAIRMAN: Is that sufficient?

Mr. KENNEDY: Yes. I should think it is 2 ft. 6 in., or something like that.

Mr. W. CROMPTON: I always thought the difficulty in a 6 ft. seam was to get the packing. To make it a 10 ft. seam would make matters worse.

Mr. W. BRYHAM: If I had some hundreds of acres to work over again that I have worked by pillar and stall I would work them long wall now. In my early days the

long wall system was hardly known in this locality, indeed I doubt whether it was known in Lancashire at all, and hundreds and thousands of acres were then worked by pillar and stall that could have been worked and are now being worked to great advantage by the long wall method. There is however such a variety of circumstances connected with the working of mines that it is utterly impossible for any man to say that any one system is superior in all cases to the other. I have mines working at the present moment that it is utterly impracticable to work on a uniform principle. We have to use all sorts of methods—pillar and stall, and stall without pillar. Where we can get a face of 100 or 150 yards we adopt long wall, and then may come a lot of faults where we cannot have a face of 10 or 20 yards, so that you see the difficulties are so great in such mines that you cannot adopt a uniform system of working. But generally speaking where the roof is a fair roof, and where the coal is tolerably free from faults, the long wall principle is undoubtedly better, both in respect of gas and safety in working. I believe too that the production of large coal is greater in proportion than it would be by working pillar and stall. In the deep mines with which I have latterly been acquainted the pillar and stall system would be altogether out of the question. We could not in that case work them to a profit, in consequence of the amount of slack that would be produced. By working the Arley mine at a depth of 700 or 800 yards on the pillar and stall system the pillars would be so crushed, whatever size they were, that it would render the coal almost valueless. Now by working it on the long wall method we experience very little difficulty as regards the pressure, and we get more round coal than where pillar and stall is used at a less depth. I have found

that where it is practicable by working the Arley mine upon the end—with the face going end ways—more large coal is got. I have not had much experience in working on the long wall principle, but I have seen the system carried out in Derbyshire and the Midland counties. I have been in collieries there where they have been working seams nearly 8 feet thick, and there does not appear to be the difficulty which one would at first fancy there would be. The men seem to be so well up in the system of packing that they can get over the difficulty even in a thick seam, but the thicker the seam the greater would be the difficulty and the greater the cost of packing. I think we are following the Midland counties very rapidly. We are getting our men to learn how to build packs, and I think they will soon understand the system as well as the men in the Midlands, hence I hope we shall soon derive in this district all the advantages to be got from the long wall system.

The CHAIRMAN: I have for several years worked almost all the mines in the Wigan district, and almost all the seams on the long wall system, the Arley being the only exception. With the Pemberton five-feet and the Pemberton four-feet I have done very little, but with the Arley mine I have done next to nothing. The Ince yard, four-feet, seven-feet, the Wigan five-feet and four-feet, cannel, and the Arley yard coal are now all worked long wall more or less. In the Ince mines we fire shots with the long wall. In the Wigan mines the five-feet requires no powder. The Wigan four-feet is a very strong coal, and at present we do not fire any shots in the long wall. The Wigan six-feet has been my greatest difficulty. It is fully six-feet thick, and I need not tell you that most of the Wigan six-feet coal gives off a very great deal of gas. The great difficulty of working long wall in this seam is in the packing, for the extra

expense arises principally from packing. The opposition to the long wall system came in bygone times from the men, but I think that the feeling of opposition to it has been practically removed, seeing that the labour of the collier is very considerably reduced by working long wall. In working the six-feet I find it works best, generally speaking, on the principle recommended by my friend, Mr. Bryham, that is to work the face partly on the end. The top part of the six-feet is very tender, and the bottom part very hard. We "hole" on the top, but it requires very little holing there, and is easy work. The adoption of the long wall system is in reality only a question of expense. I am sorry, that having come unprepared to take part in this discussion, I cannot tell you what the extra cost is, but it is considerable, and arises from packing. Now, with regard to ventilation, the general safety of any of these mines, not only in point of ventilation, but in respect of other causes, falls from the roof particularly, is greater when working on the long wall system than it is when they are worked by the pillar and stall method. I think there ought to be some limit to the length of the face in a fiery seam. I have seen, some years ago—not in this county—a face of about a thousand yards long, and where that is carried out to such an extent, whether shot firings are allowed or not, it is extremely dangerous. I believe at certain times of the day, when all the colliers were fully at work, that the last few places nearest the return were actually foul whilst the men were working, but experience has brought about modifications of the system. I think we made a mistake in this district, when we first introduced the long wall system, but it was forced upon us. I believe it would have been better for both men and masters if that mistake had not been made. The masters took upon them-

selves the packing, the result is this, that what roof comes down near the face and what dirt comes out of the mine is all thrown higgledy-piggledy behind the men, whereas in the Midlands the collier places the stones and the dirt he gets he forms into a good wall to begin with. Here, however, the dataller employed at night has to do this, as it were, a second time over. I need scarcely say, having said so much already, that I am decidedly in favour of the long wall system. I do not believe there is any seam in this district—except where there are peculiar circumstances, and unless it be the six-feet—which cannot be worked quite as well and quite as safely by long wall as by pillar and stall.

Mr. Martin: The inclination of a mine with reference to ventilation must be important in the long wall system. In thick, flat-lying mines, which give off large quantities of fire-damp, there must be difficulty in thoroughly ventilating the goaves, where there is not sufficient rubbish for filling them up completely, or nearly so. I think that rather much is claimed for the system of long wall, in attributing to it, and to it alone, the immunity from explosions enjoyed by some districts as compared with others. Circumstances vary so much as to the quantity of gas given off, packing material available, &c., that a comparison cannot be made very well without details being fully set forth. In the neighbourhood of Manchester, packing and walling is, as a rule, well done; the colliers do it themselves as they get the coal. Mr. Longbotham's argument is an important one, as, if owing to any system less lives are lost from explosions; yet more from falls of roof, before advantage can be claimed the total accidents and not only those from explosions should be compared. I must not be misunderstood as wishing in any way to deprecate the long wall

system, as I believe that, if details are carefully attended to, it can with advantage be more extensively applied than at present. It is not always necessary or possible, in order to obtain the benefit of the system, to have one long and continuous face. The question as to working out long wall from the pit, or working back from the far end, is in fiery mines of no small importance, and is one which allows of discussion. It would be interesting if figures could be given showing which method of working is the safest, most economical, and allowing of largest wages to the men and profits to the master, the circumstances for each being as similar as possible.

The CHAIRMAN: As Mr. Smethurst has a paper to read on "Explosives used in Mining," I would ask Messrs. Grimshaw and Phillips if it would be agreeable to them if the discussion were now adjourned to a future occasion, when we could be prepared with figures and better able to continue it.

Messrs. GRIMSHAW and PHILLIPS having expressed their assent, the discussion was adjourned.

EXPLOSIVES USED IN MINING.

BY WILLIAM SMETHURST, F.G.S.

It was my intention to have continued the paper upon Safety Lamps, the first portion of which was read before this Society some time since, but for several reasons I am unable to do so at present. The principal reason is that the Royal Commissioners are, at considerable cost and a very great amount of trouble, at the present time carrying on elaborate and I may say very exhaustive experiments with my apparatus, and the noted six feet mine gas, at our Gars-

wood Hall Collieries, so you can understand that until the Commissioners have completed their experiments I can not say anything upon this subject.

I have therefore chosen the next important subject to the lighting of mines, and I trust I may pave the way to a discussion upon this subject which will not end here, but will be the means of bringing out by future experiments safer methods of blasting in mines than those at present followed.

Before giving you a description of the experiments carried out at Brynn, I should like to say some little upon the abandonment of explosives in mines altogether. There is a very strong feeling in the minds of many persons directly and indirectly connected with collieries, but more particularly from the representatives of the workmen, that the system of blasting in mines is almost at an end, and there is little wonder the representatives of the colliers should strive to take away this great danger, and I should not be surprised to learn that when the Commissioners have finished with safety lamps they intend going into the question of blasting.

Now suppose the Goverment passed an act preventing powder or other dangerous explosive agents being used in mines, and we were forced to fall back upon all the mechanical appliances we could bring to bear upon our coal getting; what would be the result? At least half the mines would be unworkable; and through these mines being given up, in a large number of cases it would mean the ruin of the colliery; and other mines, which when worked in conjunction with the mine where blasting was carried on could be made to pay, would have to be abandoned immediately as unprofitable to get alone.

We should also lose some of our best household coals, and certainly most of our hard shipping coals, not from the fact

that they could not be got without powder, but that the extra cost would throw them out of the market. It would also give the proprietors who happened to have very thick mines a very great pull over their more unfortunate brethren in several ways.

Again all the colliers of the present day would require educating in the altered mode of getting the coal brought about by the abolition of blasting, more per ton would have to be paid them, and I am not wrong in saying that a great number of colliers would find some other employment rather than face the increased hard work.

I should also like to ask how much the danger and risk to the collier and all others working in mines, would be lessened by the abandonment of blasting; take some of the dangers the miners are at present liable to where shot firing is allowed.

Let us first take blown out shots. These are very serious and dangerous, several of our explosions being traced (according to the evidence) to this danger; but outside explosions, a blown out shot without the presence of gas has often been known to result in loss of life and serious damage to property. Then you have shots hanging or missing fire; to protect the workman from accident in these cases, a special rule is made that the workman shall not return to the missed shot until after the lapse of one hour; still we have accidents from this cause.

Coming to the more serious dangers arising from the use of gunpowder and other explosives, we have explosions traced to the firing of a shot. I for one look upon this as a danger that ought not to exist. If a mine is so near the explosive point that it only requires the firing of a shot to cause an explosion, there is something wrong; but you have dangers which cannot be guarded against. There may take

place an outburst of gas just at the moment of time, to be lit by the firing of a shot, and there have been several instances where this has occurred.

Again there is a theory, and at present a very strong one, that in very dusty mines, where the very fine dust is carried with the air, that the concussion and flame given out by a shot being fired is sufficient to cause an explosion without the presence of gas. I may say here in answer to this, that, so far as my experiments have been carried to test this theory, no explosion can be caused unless gas is also present. The result of the experiments with dust from different parts will no doubt be made known to you and the mining world when completed by the report of the Royal Commissioners, who are making them.

Looking through the summary of deaths caused by explosions of powder and other blasting agents in 1879 (that is, the Blue Book for 1879) in the whole of the mines of Great Britain and Ireland, I find very few recorded in comparison with other causes.

The number of deaths from this cause is 13 as against 426 from falls of roof and sides in mines. But you will say I have not taken in the explosions of fire damp, which may have been the result of blasting. Suppose I take the whole of the deaths caused by explosions of all kinds; I bring the number up to one hundred and ninety-seven in the same year, or two hundred and twenty-nine less than the number from one other cause, out of the many the mines are liable to. Or to put it in another form, the deaths caused by explosions of all kinds represent only about one-fifth the number from other causes, still there is no excuse that this one-fifth should not be saved, if it is possible to do so.

If as I have previously remarked, if mechanical appliances had to be put in the hands of the collier, the most likely one would be the wedge. Now everyone conversant with

mining knows that no light hammer must be used to wedge down coal, and also that in a vast number of cases when you bring down a large body of coal at once, portions of roof will very likely come with it, and from the position the collier must naturally be in, you can scarcely feel astonished if he very often gets buried by a fall of roof taking place. The cracking of the coal in wedging it down, can easily drown the much less noise of a creeping roof, and where the mine is a thick one it does not take a very large stone to do a man a serious injury; you must not take falls of roof as the only dangers attending wedging, there is the danger of the coal coming upon the man without giving him time to step back.

Taking these increased dangers, we should certainly swell the very large number of deaths by falls of roof and sides. You have other mechanical appliances for coal getting, but you will find they are all subject to the same, and in some cases worse dangers than the wedge. There is one mechanical appliance by which compressed air is made to force down the coal; in this case the operator must be close to the coal he is forcing down, and must run the risk of being battered to pieces when sufficient pressure has been attained to produce the desired result. Then you have hydraulics and other slow means, still you have the same risks I have just mentioned.

A vast amount of money and time has been spent upon mechanical appliances for getting coal, but so far as I know, and from what I have seen, there has been no attempt crowned with success.

In addition to their failing to do the work required, the cost which would be added to the production of the coal would be sufficient to condemn them.

The mechanical appliances brought out so far absolutely mean more labour, cost, and danger, than that run by the

miner if he used (as in the ancient days) his pick and old-fashioned wedge.

We are, therefore, thrown back upon blasting or the use of explosives.

Supposing some method could be devised, whereby blasting could be carried on without the present dangers, or at least reducing them to a minimum, it ought to be followed, and if necessary made compulsory. But the questions which will naturally be asked, will be, Can this be done? And if so, by what means? Why has it not been made public? Can an ordinary work-person manipulate it? Will it bring with it other sources of danger which in the balance would be a greater loss than gain?

You all know under what restrictions powder is being used in our mines, and I have previously stated the dangers attending its use. Much has been done to lessen that danger both by Parliamentary legislation and by the colliery-owners. In seams which are more than ordinarily fiery, blasting has been carried on in the night, when the risk to numbers has been reduced to those only who are expected to take care of themselves. This system cannot be too highly commended for a good many reasons.

If anything disastrous happens, the loss of life is very small in comparison to what it would have been had the mine been in full work. The men chosen to do the work are men who understand what they are about, and know their lives are in their own hands. They examine and charge each hole, and if they charge and fire a doubtful shot, it is at their own risk. They can also choose where they shall begin each night, and have no need to run backwards and forwards over the pit as in the working time they would have to do to keep every man going. They become better judges of the amount of powder or other explosive required to do the work; and not the least of all

the advantages in this system, they can always have fresh air with them. This, as you know, is a very important consideration. Where shots are fired in the working hours, some on the intake and others on the return side of the workings, it very often occurs that the shot-lighter has to examine the place or adjacent places, to see if they are clear from fire-damp in a smoky atmosphere; and it is unnecessary for me to say what disadvantages he is under when this happens to be the case.

Coming to the experiments which have recently been made at our Garswood Hall Collieries. I will place them as we began, Dynamite first.

This explosive agent has been tried over and over again for mining purposes with but little success (except for sinking,) its suddenness of action being one of its greatest failures, an action very objectionable for many reasons in coal getting.

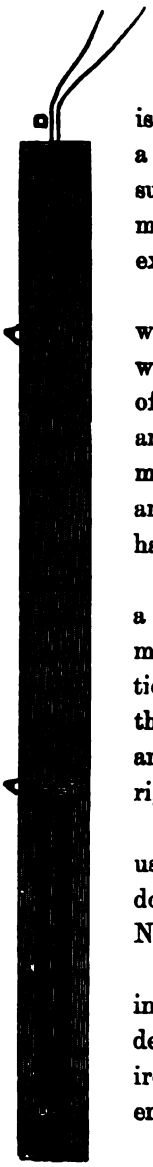
When exploded, in place of its bringing down the coal half across the place or a proper width in comparison with powder, it either cuts out a narrow slip or forces only the front part of the whole away.

The drill holes always being very near horizontal, (except of course in sinking) it has to be pushed to the far end of the hole with some instrument, and you have not the advantage of tamping as in sinking, in the latter case water being sufficient, to say nothing of the danger of driving dry tamping (where it is used) against it in the hole in its crude state.

Then you have the fumes given off by an explosion of dynamite, a feature in itself sufficient to condemn its use.

It is said dynamite does not need tamping, but I can only say from experience, that if it does not blow out like powder still it does blow out, and you lose a very great amount of force, and the fumes given off where it has not been tamped

are such that no person could possibly stay in them and follow his employment.



But I believe a means has been found out by which it can be used without these disadvantages, and to these means the country is indebted to Professor Abel, who has spent a vast amount of time and trouble upon the subject, and it was through him I first began making the experiments with this and other explosives at Brynn.

About nine years ago the system of using water with explosives was discovered and worked out by Professor Abel, and his method of applying detonating charges of dynamite and other detonating agents to blasting in mines is certainly wonderful, and all this time and trouble which the Professor has taken have been solely for the benefit of the miners.

In 1876 Dr. Macnab took out a patent for a cartridge with which he used water, but his method, both with regard to cost and application, would never do for colliers. He used the water separated from the cartridge with an elaborate system of firing, still he is in the right direction if he were less costly.

I will first explain to you the cartridge I used for the experiments, and to enable me to do this better let me take you to the Drawing No. 1.

This represents a cartridge to fit a hole two inches diameter, and three feet four inches deep. The outer case A is made of thin sheet iron or tin thirty inches long, with the back end sealed with the same material.

The inner case B, made of any material so that it is waterproof, contains the explosive—in this case dynamite.

As near the back end as possible you have the detonator C, and from this you have the two wires D D left long enough to reach outside the shot hole and couple to the wires of the battery or other firing machine. The whole of the remaining space inside the case A is filled with water and sealed up.

There is no reason why the outer case A should be made of metal. Paper or other cheap material made sufficiently strong to carry the water and to be pushed into the hole would answer the purpose just as well.

The Professor first tried the cartridges upon blocks of stone and iron with very good results. Afterwards at his request we tried them for blasting coal in our Wigan four feet mine, which in some places is very hard to get. In our first trials it gave us very great encouragement, the principal drawback being the result of our not knowing the amount of dynamite required compared with powder, the charges proving too small. In the first trials we left the mouth of the shot hole open, not using any tamping; afterwards we found by using a little the charges acted quite differently.

The amount of powder used in this mine by the collier ranges from eight to twenty ounces. Our first cartridges were charged with from three to four and a half ounces of dynamite; this, as I have previously stated, we found insufficient to do the work, the fact of its being surrounded with water seemed to lessen its suddenness of expansion and violence.

The very first thing which arrested my attention was the very small amount of unwholesome gases given off; and where a small quantity of tamping was added I could immediately go into the place where the shot had been fired to find it perfectly clear—a very great advantage to the person

who fires the shots, and making it much easier to carry out No. 37 of our Special Rules.

In the first series of experiments made, most of our shots were blown out. This helped us in our first object to satisfy ourselves upon the amount of flame (if any) given off by these cartridges, and this we were able to do from the nature of the shots.

Even where tamping was *not* used, and where it was undoubtedly a blown out shot, no flame was given off; but a kind of sparks or incandescent matter was ejected from the mouth of the hole.

The weight of the charge was then increased to from four to seven ounces according to the amount of work required. These doing their work produced not even a spark.

We found the proportion of dynamite to powder required to be about one-third, and where the shots did their work there was not the slightest trace of obnoxious gases usually given off by dynamite, showing that the water had the effect of destroying them. To prove this more conclusively I charged one or two holes with bare dynamite, and without the water cartridge, and the fumes given off by these shots were so dense that we could scarcely see our lights and we all were seized with violent headaches.

Coming back to the blown out shots, we tried several with a charge of from six to seven ounces of dynamite in the water cartridge, to prove if the sparks thrown off increased in proportion, or if there was any sign of flame. All our lights were covered and we were within ten yards of the shots. One or two blew down some brattice which was placed about four feet from the hole, and even in these cases the sparks (or before mentioned incandescent matter) did not reach that distance.

The result from the workman's point of view was surprisingly different by the use of the water cartridges as

against dynamite by itself, for instead of blowing a narrow cutting, or forcing away the front of the hole only—one of the faults of this explosive—it did its work as near like powder as possible, not only extending a proper distance across the place, but cutting fairly into the fast side. After a good many trials with shots fired singly, we proceeded to fire the two shots (one at each side of the place) simultaneously, with very satisfactory results to the colliery proprietor, the whole of the coal being brought down in one solid mass.

I ought to explain our system of lighting the shots. We used a small dynamo-electrical machine, simple to handle and very easy to carry, by which I could fire as great a number of shots as would ever be required to be fired in a mine at once.

Before leaving this subject, I can only say that our present system of shot lighting ought to be at once condemned. It would be no use whatever, and the time would have been wasted, were we to attempt to arrive at a safe method of blasting, and still preserve our present system of lighting with the fuze and wire. Why electrical firing does not come into general use I cannot understand. In the first place a shot-lighter can not only examine the place where the shot has to be fired and the adjacent ones, but he can actually place himself in a safe position before attempting to fire. This he is unable to do with our present system, but must bolt immediately he has lit the fuze. Besides this, everyone becomes quiet immediately before the shot is fired, and if a stranger happens to turn round a corner and place himself in a dangerous position for the shot, the operator has no need to let it go before he is removed, in fact, he has the shot entirely under his control. We should have no accidents from missed shots, and there would be no danger of returning to the place (even if the shot would not go off)

No 2.

after the wires were uncoupled. Both shots, or three where the latter number was used, could be fired simultaneously, thus reducing the liability of blown out shots, from the very fact of one shot helping the other. Less powder or other explosive would be required where two or three shots could be fired together.

There was a difference which I noticed between dynamite and powder; the latter invariably blows the coal from beyond the end of the holing, but the former only cuts straight with it.

Leaving dynamite and taking powder, I followed the same line of experiments, with the following different results.

In blasting the coal there could be nothing said against the manner in which it did its work, and there is no doubt that it is superior to any other explosive for mining purposes (except its danger).

Out of a good many shots fired with this agent enclosed in a water cartridge, we had only two we could say were void of flame.

This I attribute to a very simple cause.

Take the sketch (No. 2) of a cartridge containing a charge of powder equal in power to the one containing dynamite. You will find the powder takes up so much of the space which should be occupied by water, that there is not sufficient left for the required object.

Again, the flame from powder is much more dense than that produced by any other explosive, and for this reason requires more water and not less.

But even with the small quantity of water contained in the cartridge, the effect was something wonderful. In place of the great body of flame usually given off by this agent there was very little, and also considerably less smoke, still there was sufficient flame given off to ignite gas had there been any.

After days of experiments with both fast and blown out shots, the question arose, Would the incandescent matter given off from a shot which had not done its work, or which had blown out, light gas if any had been present? This was a very important point, and I was determined to give it some very severe tests.

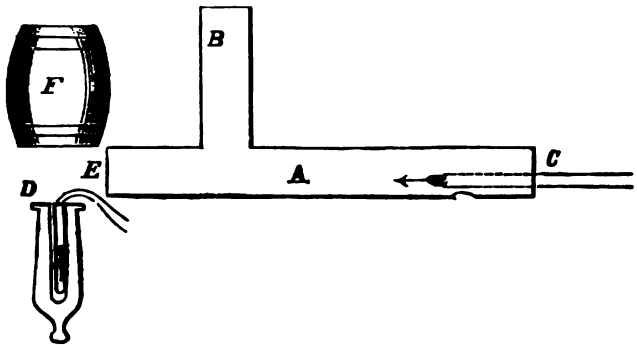
I had cartridges made similar to those we had used down the pit, and having so much gas on the surface brought up in pipes from our six-foot mine, I was able to do this with very little trouble.

I inserted a cartridge in a very strong cannon and placed the outlet of the large gas pipe in close proximity to its mouth to see if I could fire the gas. After several attempts, which resulted in the bursting of the cannon, I failed to light the gas. This I thought might be because the expansion caused by the explosion of the cartridge drove the gas back up the pipe and so did not give it a chance of being lighted.

I next had a box made about eighteen feet long, A, and from the box, about four feet from its end, an upright one, B, eight feet high. Putting in the gas pipe C, at one end, and arranging at the other (from which the gas was issuing after having filled the upright one B) the cartridges D, I tried the end of the box at E, to see if the gas was working properly through, and found I could not get nearer that three feet without its firing in the lamp.

This I thought would be a fair test, still I failed to ignite the gas with dynamite cartridges, but succeeded several times in doing so with those charged with powder.

Nº 3



I then placed an inverted barrel F, over the mouth of the box at E, which filled with gas.

I then exploded a cartridge in the cannon which blew straight into the barrel.

I again failed with the dynamite cartridge and succeeded with the powder.

After making all these trials, upon one of the visits of the Royal Commissioners they desired them to be tested in their presence. At night, when it was dark, and we could see any flash (if there had been one), I placed one of the dynamite cartridges in my model workings close besides a window, in a drift opposite which, and in the drift, I placed a Davy lamp. I then turned into the workings an explosive mixture at about 600 feet velocity, and Mr. Pickard, who has taken a very great interest in all my experiments both with explosives and safety lamps, was satisfied that the lamp could not have lived more than six or seven seconds in the mixture. I then withdrew the lamp and discharged the cartridges, but without causing an explosion, and yet in the same mixture and in the same place a small Abel's electrical fuze was sufficient to do so.

Now let us take the comparative cost of blasting, beginning with our present system and using the same force in each case.

	d.
Say 1lb. compressed powder	6
Fuze, 4 ft. 6 in.	1
	7

WATER CARTRIDGES.

	s.	d.
Compressed powder	0	6
Inner cartridges	0	2
Outer ditto	0	2½
Wire fuze, &c., say	0	3
	1	1½

WATER CARTRIDGES.

	s.	d.
Dynamite	0	9
Inner cartridge	0	1½
Outer ditto	0	2½
Wire fuze, &c., say	0	3
	1	4

So taking the difference between our present system and the water cartridges, if adopted, you have an extra cost of 6d. per shot, or, at the outside say 2d. per ton, which I have not the slightest hesitation in saying would be covered by less breakage in the coal and a saving in time from the improved method of firing.

I have put the cost of cartridges, fuzes, &c., at a very high value; there is no doubt they could be made at much less cost by the numbers which would be required. Why should they not be made of paper instead of tin? Or what is there to prevent the makers of dynamite and powder from covering the cartridges with a waterproof coating, which

would add very little to the present price per lb? I don't think there would be any difficulty in doing this if the Manufacturers knew the weights of charges required.

Now, in conclusion, it may be said there is not much about these experiments new, and that there are places at present using water cartridges. But I think you will find in those cases it is a water cartridge with the charge, not the charge surrounded by water. I have tried this, but I can assure you the results obtained do not bear comparison with the latter method, still it is a step in the right direction.

I have not mentioned in this paper gun cotton, and one or two other explosive agents, knowing I should be wasting your time, so far as mining was concerned, the chances of their being used in mining being so remote.

A vote of thanks was unanimously passed, thanking the Mayor of Wigan (Mr. Lamb) for the use of the room.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VI. VOL. XVI. SESSION 1880-81.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 29th day of March, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

E. W. BINNEY, Esq., F.R.S., Vice-President, in the Chair.

Mr. Richard Charles Aubrey, Standish, Wigan; Mr. William Bryham, Junr., Douglas Bank Colliery, near Wigan, and The President (for the time being) of the School of Mines, Columbia College, New York, were elected ordinary members.

The following donations and books purchased were laid on the table :—

Transactions of the Epping Forest and County of Essex Naturalists Field Club, Parts 1—3, Vol. I., Rules, &c.—*From the Council.* Quarterly Journal of the Géological Society, No. 145.—*From the Council.* Transactions of The Mining Inst., of Scotland, Part 10, Vol. II.—*From the Council.* Catalogue of Books added to the Radcliffe Library, Oxford University, in 1880.—*From Dr. H. M. Ackland, Librarian.* Journal and Reports of the Royal Institution of Cornwall, No. 23.—*From the Council.* Transactions of the S. Staffordshire and E. Worcestershire Inst. of Mining Engineers, New Series, Vol. IV.—*From the Council.* Geological Magazine, Nos. 197-201. *Purchased.* Journal and Proceedings of the Royal Society N. S. Wales, Vol. XIII. 1879. Reports of the Department of Mines, Sydney, with Atlas, 1879, and for 1880.—*From the Society.* Bulletin of the Museum of Comparative Zoology, Cambridge, U.S.A., Parts 1-3, Vol. VIII.—*From*

Prof. Alex. Agassis. Annales de Société Géologique du Nord, Lille, Tome VII., 1879–80.—*From the Council.* Mémoire sur Les Phénomènes d'Altération des Dépôts Superficiels, par M. E. Van den Brock.—*From the Author.* Sitzung's Bericht (1–12, 1880) der Naturwissenschaftlichen Gesellschaft Isis in Dresden.—*From the Society.*

The CHAIRMAN read a letter from the President, Sir U. Kay-Shuttleworth, Bart., stating his inability to attend, and intimated, further, that Mr. W. J. Black, who was to have read a paper on "A visit to the extinct volcanoes of Auvergne," had also written expressing regret that he could not fulfil his engagement.

EMBLETON'S RING FOR TESTING SAFETY LAMPS.

Mr. DICKINSON showed one of the Embleton Rings for testing safety lamps by gas. He said he understood it was the invention of Mr. Thomas W. Embleton, of Methley. It is nearly six inches in diameter, outside measure, with an entrance pipe at one side for gas to enter, and is made of half-inch copper tube, having twenty-four small jet holes inside the ring facing where safety lamp has to be placed. He said he had seen it in use, and also the box or case test, and of the two he inclined to the opinion that the ring was the better, as it makes less commotion in the event of the lamp proving insecure and firing the gas.

At the Miners' Conference, held in Manchester, in February last, a resolution was passed with the view of having a test by gas made compulsory, but, of course, that could only apply where gas was available for the purpose.

The CHAIRMAN said: There could be no doubt that anything which could add to the safety of what was not

altogether a positively safe lamp should be looked at with very great interest. It was, he thought, 30 years since instances were mentioned in that room of explosions arising from the so-called safety lamps. Explosions were a source of great loss to proprietors, besides involving a lamentable sacrifice of life; and no proprietor, he was sure, would object to go to any expense if he could prevent them. He would like to know the opinion of practical men as to the value of the ring test.

Mr. GREENWELL: I suppose it is intended to send the gas with some pressure through that ring?

Mr. DICKINSON: It is simply connected with the ordinary gas main.

THE ASHTON MOSS FOSSILS.

The CHAIRMAN said: At one of the late meetings of this Society my name was mentioned in connection with some fossils which had been found in the sinking of the Moss Pit, at Ashton; and it seemed to be implied that I thought there were no shells of the particular kinds named to be found above—I think it was—the 40 yard coal. Many years ago I did publish an account giving localities where *Aviculopecten* and *Goniatites* were found, but I by no means meant to say that they did not extend further up. I could only say that, so far as I had seen, I had not met with them; therefore, when they did occur in the Tame, at Dukinfield, I went to see them, but I was not then thoroughly convinced that those shells were exactly proved to be in the position of the Middle Coal Field. Since those have been found at the Moss Pit, I have no doubt whatever that they do occur a long way above where we have found them before: not that I mean to say that those, or any other shells, indicate thoroughly the nature of the water. The water that has

generally been found in deep coal mines, so far as my knowledge extends, has been salt water when the surface water has been kept out. Therefore, for the last 40 years, I have held that our coal measures were deposited most certainly in salt water, because when we now find the mother-water, as it were, in the seam, it is in association with iodine and bromine. I by no manner of means believe that fossils altogether are to decide the superposition of the strata, though they help us a great deal, and I am thoroughly convinced that the fossils from Ashton Moss—which we should in all probability have missed if it had not been for the keen observation of Mr. Wild—do show that such shells occur in the upper part of the Middle Coal Field.

Mr. Dickinson: Of the upper coal field, I think.

The Chairman: I hardly think the upper. Of course there is a great question as to what exists between Ashton-under-Lyne and the Manchester coalfield; but the boundary of the upper coalfield—the lower boundary—is the 4-feet coal, and I think you must take the seam they have found at the Moss to be lower down than the Manchester 4-feet. It is a subject which, save for time, I should like to have discussed—as to what does really exist between the Manchester coal-field and the Ashton and Oldham coalfield. It was with the commencement of this Society that discussions began as to how the two are connected. There is a sort of gulf we have never been able to bridge over, but I should like to see a further attempt made. I shall be happy to give whatever information I have, and Mr. Livesey and others have always shown a great desire to give us the benefit of any knowledge they possess. Do you think, Mr. Dickinson, the Ashton Great mine may be in the upper coalfield—above the 4-feet?

Mr. Dickinson: No, but these fossils are a considerable way above that. The Great Mine, and the Roger Mine, which

lies below it, I take to be the representations of the Shuttle and Crumbduke of the Pendlebury series.

The CHAIRMAN: They are in the middle field.

Mr. DICKINSON: Yes, the Shuttle and Crumbduke appear to form the Roger Mine, both by the appearance of the coal, the roof, and the general surroundings.

Mr. GREENWELL: There is one point further. Take what is the middle coalfield—a part of the North of England measures—you have there the high mine which lies about 60 fathoms, or 120 yards, above the low mine, and you find occasionally, water far more salt than the sea itself, though it is nearer to any percolation there might be, of surface water, than the mine below. When you get some 120 yards lower, there you find brackish water of the description spoken of, that might have been sea water rendered less salt by intermixture with surface water. Its brackishness does not, perhaps, indicate the original character of the water, because you are met by the fact of that which is nearer the surface being so many times more salt than the sea itself.

The CHAIRMAN: It is possible that some of the pure water may have combined with the rocks. All I contend is this—that any one who talks about the water in which the coal was deposited must first get quit of the salt water before they begin to speak of fresh.

A REPLY TO RECENT ARTICLES ON COLLIERY EXPLOSIONS WHICH HAVE APPEARED IN THE PAGES OF THE *NINETEENTH CENTURY*.

By Mr. HENRY HALL, H.M. Inspector of Mines.

The majority of the Members of this Society, will no doubt have read the different articles which have recently appeared in the *Nineteenth Century*, and which are the subject of this communication, the most important is the contribution of Mr. Plimsoll.

Mr. Plimsoll is not by profession a Mining Engineer, and cannot be expected to be familiar with all the innumerable schemes for the prevention of Colliery Explosions, which from time to time, have made their appearance, and have been cast into the waste paper basket, if it had been otherwise he would probably have spared himself the pains and trouble of thinking out, and bringing under public notice what he calls his invention for getting rid of the fire-damp in mines, but I think you will agree that his proposals have a claim upon our candid consideration. It is true that other thoughts than his had already travelled the same path, and it must at any rate be satisfactory to him to know that he is in good company.

In the year 1844, Professors Lyell and Faraday in a report on the Haswell Colliery Explosion, to Sir James Grahame, at that time Home Secretary, submitted a scheme precisely similar in almost every detail to the most prominent of Mr. Plimsoll's suggestions, indeed, I believe that even at an earlier date than this a Mr. Ryan suggested iron pipes from the upper parts of goaves, and thence to the upcast shaft as a likely means of dealing with fire-damp.

The report of Messrs. Lyell and Faraday was considered of so much importance, that it was submitted to a committee of the prinicipal Mining Engineers of the North of England, of whom a Mr. Johnson was chairman. These gentlemen, in very decisive language, condemned the proposals as to iron pipes, as being impracticable, both on account of its cost—they stated that to fit the Haswell Colliery with the apparatus, would cost at least £21,000, and, also, that even admitting that the question of cost could be overcome—on the ground that it would not be efficient, because they were of opinion that different sections of the same goaf, and containing fire-damp, did not always communicate with each other, that is, that falls occur in

such a way as to isolate one part from another. Mr. Matthias Dunn condemned the proposal for much the same reasons.

But it by no means follows that a suggestion made and rejected forty years ago, is necessarily worthless. The writer was fortunate enough within the last two or three days, to have the opportunity of perusing the report of the two Professors, as also the criticisms, and these last, although most interesting, do not appear likely to be accepted by Mr. Plimsoll, should his attention be drawn to them, as an incontrovertible proof of the impracticability of his proposition. The critics have laid too much stress on the question of cost, and the reasons for their adverse opinion are not detailed with a clearness and precision likely to satisfy an inventor. We know that an inventor is proverbially difficult to convince, but in this particular instance, there seems to be some grounds for his being of the same opinion still, or at any rate, there is room for further inquiry.

The following remarks are directed to this object, and embrace briefly the whole of the suggestion brought under notice by the authors of the different papers.

Mining Engineers, like their fellows in other professions are liable to be prejudiced, and to give little consideration to suggestions coming from an outsider, but those we now propose to review, cannot have failed to attract. No charge is made, either of want of skill or care, we are simply asked almost defferentially—Cannot you do this? would not so and so, be an improvement. This is especially the case in Mr. Plimsoll's article, the first and most important we have to deal with. Mr. Plimsoll is far too experienced a politician to offend those whom he seeks to persuade to act with him.

Let us see then, and if possible without any leaning to

preconceived notions, but profiting of course, by previous experience—"notions" and "experience," are very different things—whether, any of the hints given can be taken with us underground, and moulded into such a form as to give a fair promise of increased security in working fiery, or dangerous mines. Motives are assuredly not wanting to urge us to give every suggestion a fair trial, nor is the vivid description which Mr. Plimsoll gives us of the pitiful results of explosions required to stir us up, personal contact with such things affect one much more deeply than written descriptions, and few mining men escape such sad experiences, many meet them in the collieries, for the safety of which they themselves are responsible, and others whilst rendering assistance to their loss fortunate neighbours. The pecuniary loss to the owners of Collieries, where such catastrophes occur is also immense as evidenced by the very recent accident, at Seaham. There is no Insurance Company as in the case of shipping, whose broad shoulders bear the burthen for them.

From careful study of Mr. Plimsoll's article, I gather that the author believes, that there are at least three or four directions from which a possible cure may come, and he asks four principal questions, which are backed up by various arguments and reasons, why they should be answered in the affirmative. It would be tedious to recapitulate the whole of these arguments, I will therefore, simply abstract, and try to answer each question in its order, but will endeavour to make the reply embrace, as far as possible, the whole view of the subject, to which the inquiry relates.

Question 1, page 896.—"I have said to myself that if "this gas (fire-damp or light carburetted hydrogen CH_4.) "were visible to the eye like smoke, or steam, that many "accidents that have occurred, would have been averted, by "the immediate retreat of the men from its neighbourhood."

"Can we unmask this gas? Can we make it visible to "the eye like smoke or steam? Or, failing that, can we "make it reveal its own presence by some automatic means, "as sulphuretted hydrogen, for example, can be made to "reveal itself by acetate of lead?"

Again and again means have been devised to attain this object, and in some cases with complete success. There is a beautiful little instrument called "Ansell's Fire-damp Indicator," which depends for its action upon the law of diffusion of gases; a lighter gas passing more freely, and mixing or diffusing more readily than a heavier, this difference is taken advantage of to move a needle over the segment of a circle similar to an Aneroid barometer, and thus to indicate the quality of the atmosphere of a mine; the same instrument can also be so arranged that when a mixture of air and fire-damp is present electrical contact takes place, and a bell rings. Another instrument of this description has been lately invented by Professor George Forbes, of Glasgow, and described very recently before this Society.

All these contrivances have been worked at and invented by persons unfamiliar with the underground workings of mines, and have proved to be labour lost, because every miner carries in his hand (his Davy Lamp) an almost perfect test of the character of the atmosphere he passes through and labours among; his lamp, by the varying "cap" (a blue halo on the top of the flame) warns him if fire-damp be present even in a proportion much below what is needed to make air explosive; it tells him if carbonic acid is being given off, by almost refusing to keep alight, and constantly requiring the wick to be trimmed, and finally the frame-work of the lamp gets hot and burns his fingers if the spot where he is engaged is deficient of proper ventilation, even in the absence of any noxious gas. It is true it does

not warn him in the case of fire-damp until there is about four per cent. present in the air, but even, if it achieved this also, it would serve no purpose, as far as the miner himself were concerned, because he cares nothing for its first admonitions, and pays no heed until the air gets so bad that it becomes actually explosive. What then in such a case would be the utility of a more delicate test? And if by the employment of some chemical, as suggested by a reference to calico printing, we could compel fire-damp to write up its own name wherever it had collected, neither miner nor official would be greatly alarmed. The active official and his deputies know thoroughly well the state of the mine *in its normal condition*, they are aware where the gas is emitted and where it is accumulated, except perhaps in the unapproachable parts of the "goaves," or exhausted workings, and such places are barred equally against chemical signals as against themselves. Any sudden outpour of fire-damp from falling roof or "blowers" (outbursts) is as likely to be quickly detected by a lamp as it would be by any of the apparata suggested.

The risks of mining do not consist so much in the difficulty of discovering the dangers from day to day as in coping with and overcoming them; and what we seek is more skill to meet them, rather than any delicate test of their presence.

Question 2, page 899.—"Next I put the question: "Supposing all these branches of inquiry to result unsatis- "factorily, whether this gas should be loaded or neutralised "in some manner that should render it non-explosive?"

I believe quick-lime has been tried to attain this result, and was found injurious to both the eyesight and respiration of the workmen.

In the *Times*, of the 9th of December, the following occurs:—"Prevention of Explosions in Mines.—At a meeting

"of the Monmouthshire and South Wales Sliding Scale "Committee, held at Cardiff yesterday, Mr. Taliesin Jones, "of Rhymney, laid before them the results of five years "study and many experiments for the prevention of explo- "sions from coal gas in mines. His scheme consists in "distributing through all parts of a colliery some material "which gives rise to a gas and decomposes coal gas so "effectually that the most fiery mines can be worked with "naked lights. The explanations given were so satisfactory "that arrangements were made, with the consent of the "masters, to test one of the most fiery mines in the Rhondda "Valley." I have not had an opportunity of obtaining particulars of this discovery, but it shows that others are on the same track; indeed, is not every colliery manager journeying in this direction when he forces large quantities of fresh air into the mine to dilute or so *load* the fire-damp as to make it non-explosive? I admit that this mode only effects a mechanical mixture and not a chemical combination, and sometimes it fails of its object, but not because the agent we use (common air) is an improper one, but rather in consequence of faults in the application. Its nature is simple and the *modus operandi* usually very easy and effective, but the excavations in a mine are often so intricate and extensive that it cannot at all times insinuate itself in sufficient quantity into every part; give it access, by means of an air-way, and it at once serves our purpose, supplying at one and the same time the oxygen for workmen and horses to breathe, and wafting away the noxious gases. It has been hinted as possible that common air may first take fire-damp into its arms, as it were, and afterwards tiring of the burthen, leave it on the road. I cannot say whether this is so or not, but I know that in mines, if once taken up, it is held long enough to convey it to the upcast shaft and so get rid of it.

There does not then, appear to be much prospect of discovering any medium likely to be better adapted than common air, for the purpose of safely diluting and carrying away the dangerous gases met with in mines, because the same difficulties of application would apply to all.

Question 3, page 899.— "Can this gas be exploded in "regulated quantities with safety? that is to say, if naked "lights were kept constantly burning in those parts of the "pit where the gas was found to accumulate, could it be "regularly fired, in regulated quantities that would not do "mischief?"

Years ago this idea passed through my mind, and after thinking it over, and consulting with others, I was compelled to conclude that the inevitable consequence of such a practice, would be, to set the pit on fire. In ancient times, something of the kind was in operation, we read of men whose duty it was to go down into the mines in early morning, before the general body of the workmen descended, and, being provided with a long pole, with a lighted candle fastened to the end of it, they travelled through the workings, setting fire to the gas, which had accumulated overnight, the more cautious among them wearing wet cloths over their faces.

Question 4, page 907.—This is the most important question of all, the one to which Mr. Plimsoll pins his faith, and the discovery of the method of disposing of fire-damp, which it refers to, he says, "filled his heart with joy," the others he appears only half-hearted about, they do seem like old friends, but, of this last, no shadow of a doubt has as yet crossed his mind.

Let us see if the plan is worthy of such confidence. I shall be compelled to make rather a lengthy abstract, in order to state it fairly and with precision.

He says: "I do not propose to alter anything in existing

"arrangements in the suggestion which I am about to offer, "but only to supplement them."

"Let the present system of ventilation remain as it is, in "all its vigour; but in regard to the gas which escapes it, "gets behind it, and accumulates in the upper and the "waste portions of the pit, can we not go arm in arm with "nature in this matter, as we do in others, and follow "the gas whithersoever it goes? and thus, in Lord Bacon's "words, by obeying nature, learn how to conquer her."

"It goes to the highest part of the pit, therefore into the "exhausted spaces. I would work with this tendency, and, "as in the case of water a large hole is dug, called a 'sump,' "to collect the water at the bottom of the pit, and so "facilitate it removal by the pumps, so I would make a hole "or 'sump' to gather the gas; but as the water is heavy "and lies upon the floor, and has the 'sump' for it made in "the floor, so my hole or 'sump' to gather the gas should "be in the roof of the mine, and that in the highest acces-"sible places."

"Is it more certain that the water will run into the hole "or 'sump' dug for it in the floor of the lowest part of the "pit, than it is that the light carburetted hydrogen would "rise in a 'sump' or hole dug for it in the highest part of "the workings of the pit?"

"I would then place a vertical tube with an open trumpet "shaped mouth, something like the funnel or chimney of a "locomotive, in this place, and of such length that the open "mouth (which should be protected with a louvre covering "or cap to keep out the dirt), should reach up very near to "the roof; the bottom end of this pipe or tube I would "continue to the bank of the pit; and as, in the case of "water, you proceed to remove the accumulation by a water "pump, so in this case, I would pump out the accumulation "of light carburetted hydrogen by means of an air pump

"(probably a small fan like that used in foundries would do "as well or even better.)"

"I ask your common sense could you not as certainly in "this way draw off every cubic foot of gas in the mine, as "you now can certainly remove the water from it?

"It would come of itself—would syphon itself out up the "shaft."

Such is the general drift of this new expedient for ridding our coal mines, of at any rate, an important part, of that fatal fire-damp. It is not maintained that the ventilation as a whole can be manipulated in this way, but only that portion of the gas which escapes the broom applied by our existing fans and furnaces, and collects in the "goaves" or waste places, that this can be carried safely away by means of pipes placed along the working roads, and up the shafts, that it would pass through the pipes readily and rapidly, by reason of its low specific gravity, being only half as heavy as common air, that it would in fact syphon itself out of the mine. We are also told that our fans and furnaces fail, because they are in antagonism to natural laws, and they are likened to a man trying to sweep water up a slope and who by energetic labour succeeds to some extent, but only partially, so with the fans, they are partly effective, but not entirely so, because it is an attempt to force a light gas down hill, when its natural tendency is to rise.

There is doubtless some truth in this, but the existing system does not fail because the light gas (fire-damp) wishes to go in some other direction, but because we are not successful in getting the ventilation to play into every part of the excavations. It is quite clear that if the shafts be situated at the deep or lower side of a coalfield, that any gas given off to the rise of such shafts must travel down hill, against its inclination, before it can get egress to the surface,

whatever the power may be that is used to move it. However, it is not my purpose to defend any particular mode but simply to criticise the subsidiary one proposed.

I admit at once that fire-damp does collect, and in large quantities, in those districts of a mine where the coal has been entirely removed, that is in the "goaves" or waste places, and the roof or overlying strata having fallen, these parts have become inaccessible, either for the purpose of examination, or ventilation, and I also readily agree that this gas, on account of its low specific gravity, naturally finds its way to the higher sides of these "goaves" or waste places, and that in its unadulterated form it would possess considerable syphoning force, as much as ½lb. per square inch where the column or pit shaft is six hundred yards deep; but is it the fact that it would find its way to the "sump" dug for it in the roof of these waste places, as *fire-damp pure and simple?* it is not, for this reason, as it passed slowly on its way the law of *diffusion of gases* would be constantly acting upon it, its route would not be through a vacuum or unoccupied space, but through the common air with which the open parts of the "goaf" or waste places are charged, and by the time it reached its journey's end, it would have taken to itself at least seven other spirits, in the form of seven times its volume of common air, and its latter state would, indeed, be worse than its first, because it would be now a dangerous explosive mixture, and would at the same time have frustrated any chance of our taking advantage of its low specific gravity as compared with air, to get it out of the mine. Its original weight was only half that of air, but now in the form of the mixture as pointed out, it is only about six per cent. lighter than a similar volume of air, and any syphoning force that it may have possessed originally has all but disappeared, and it completely vanishes when we consider the friction it would meet with in passing

through long lengths of, say, six inch pipes. Such friction would consume about seventy-five per cent. of whatever the remaining syphoning force might amount to, leaving only twenty-five per cent. to give the mixture velocity of travel through the pipes. That this is so is taught us by our experience of the ordinary air-ways in mines where we find that if there exists a ventilating pressure represented by twenty pounds on the square foot of shaft area, the force of fifteen of those pounds is expended on the friction met with in the various air-ways, and since the length of the pipes reaching to the different "goaves" or waste places of a mine, would be similar to the length of the different air-roads under the present system, therefore the amount of friction may be accepted as similar for like velocities. Now the area of a six-inch pipe is only about 3/16 of a foot, and it would therefore require a velocity of a hundred feet per minute to pass eighteen feet of the mixture, and since the mixture contains seven parts of air to one of gas, it would need a velocity of more than 4,000 feet per minute through the pipes to deal with a goaf giving off say one hundred cubic feet of firedamp, and this is a very small amount, compared with what some "goaves" constantly pour out, so long as pillaring, that is the clearing out of the coal, in its neighbourhood continues, and usually gas continues to be emitted for years after this work has entirely ceased, being caused by continued settling and breaking up of the upper strata over the area of the "goaf." Such a flow of gas as this spoken of, is often noticed coming in a body from the upper corner of a waste or "goaf," and to this would have to be added that which is licked up, as it were, by the ordinary ventilation as it passes along its edge. The whole of this would have to be pumped up by the pipes, because as soon as these pipes began to operate, the fire-damp would withdraw from the "goaf" edges, out of the reach of the ordinary ventilation.

Now the common velocity in the air-ways of mines is about six hundred feet per minute, and if to attain this comparatively low velocity seventy-five per cent. of the original ventilating power has been used up by friction, how then can we hope to accomplish a velocity of four thousand feet per minute?

It might be that so long as a "goaf" or waste was quite full of gas, it would press towards the higher edge or to a "sump" placed there, as a comparatively undiluted and light gas, but I understand the introduction of the new system to aim at constantly keeping the whole body of the goaf clear, with the exception of the "sump," and since in order to fulfil the conditions necessary for the expedient to act at all, we are bound to commence the total clearing out of the coal at the rise or higher side boundary, it is quite evident that as the excavations draw down hill towards the shaft and the extent of the waste increases in that direction, the flow of gas given off at or near the point where the work is progressing, must be through an already purified waste or "goaf," and become subject to the laws of diffusion of gases.

These laws are naturally the same underground as on the surface, and we know that the salubrity of the atmosphere we live in depends upon them. If no diffusion took place we would have layers of different gases resting over the surface of the earth in the order of their densities, and since carbonic acid is one of the heaviest, animal life would become impossible, but fortunately nature has so arranged that all gases mix and diffuse with each other, whatever may be the difference in their density, the lighter gas diffusing more rapidly than the heavier, and such diffusion being encouraged when the gases are put in motion by any current or force.

In mines, anything approaching pure fire-damp, is seldom

met with, either in goaves, or elsewhere, if this were otherwise, there would be far more deaths to record from suffocation, for unmixed with air, it is fatal to life. The layer of fire-damp spoken of as resting upon the air, and against the roof of mines, is always an explosive mixture, that is, it contains seven or eight parts of air, to one of fire-damp. The laws of diffusion of gases appear to operate the instant any gas is evolved.

It would be equally impracticable to attempt to create a force to draw the gas through the pipes, by means of pumps, because the seven parts of air as well as the gas would still have to be dealt with, and the velocity in the pipes would be the same as with the syphon, if applied to a goaf giving off the same quantity of gas, and any power used to give rise to this velocity, would convert the pipes into an upcast shaft on a small scale, and the air of the mine would be drawn towards the funnel shaped tube, to the exclusion of any gas that had a distance to travel before it reached the inlet, the mouth of the funnel could not be so isolated as to hinder the air getting to it, as can be done with the suction end of a water pipe.

Fire-damp cannot be manipulated the same as water, because the latter, however far it may have to travel to the "sump," neither gains nor loses weight, its specific gravity remains unchanged.

Beyond all these difficulties, it must be borne in mind, that whenever the proposed pipes were carried to, or through the goaves, travelling roads would require to be maintained, so that they might be accessible in case of breakage, to which they would be always liable, on account of the almost constant lifting of the "thill," or floor upon which they rested, and this being so, we are naturally led to ask—Why have any pipes at all? Why not draw the fire-damp through the air-ways, or travelling roads, which would of necessity have to be provided?

Thus, by force of circumstances, we are driven back to the present old-fashioned method, if you like to call it so. We find that fire-damp cannot be eliminated from the air; that air-ways would have to be maintained through which to lead the proposed pipes, and we are compelled to conclude that Mr. Plimsoll's new system would be nothing better than an attempt to achieve, by means of a six-inch pipe and a small pump or fan, that which we sometimes fail to effect with capacious air-roads and huge ventilating machines. The only hint of value that we gain from the paper is the importance of ascensional ventilation, a subject which might with advantage receive more attention from Mining Engineers than is at present the case.

The February number of the *Nineteenth Century*, contains a criticism of Mr. Plimsoll's paper, by Mr. J. Herman Merivale, and also a brief communication from Colonel Shakespear.

Mr. Merivale is of opinion, that the Swan Electric Lamp, will in the future, prove a panacea for Colliery Explosions. This lamp has recently been exhibited here, but I am unaware what are the views of the members in reference to it.

There can be no doubt, that, if the inventor succeeds in bringing it into such a form that it can be used in the same way as an ordinary safety-lamp, it would form an almost perfect safeguard against explosions of fire-damp in mines where blasting is unnecessary, and where all exposed lights of every discription are excluded, but in the presence of blasting, its usefulness would only be partial. In its present form it is hampered by long connecting wires, which would be very difficult to manipulate in underground workings, and it is liable to be rendered unsafe by accidental breakage, to the same extent as the lamps now in use. Professor Tyndall's contrivance of an outer vessel filled with water to surround

the flame, so that in case of injury to the glass, it may be at once extinguished, reminds one of the recent proposals for stemming gunpowder with water, and it is difficult to get quit of the feeling that there will be a good deal of *glorious uncertainty* about the operation. It may be that these difficulties will be overcome, but since it is only in exceptional mines, that blasting has as yet been dispensed with, it would appear that at the present stage, some safe substitute for gunpowder would be more valuable than a perfect safety-lamp. However, we should be glad to accept increased safety, even by instalments, but personally, I believe there is a better prospect of our securing a perfect safety-lamp, not differing greatly from those now in use, than of the electric light being made available.

Colonel Shakespear suggests "to tap the seams by boring "to let the compressed gas escape gradually."

He does not tell us whether this escaping gas is to be carried away by means of the ordinary air-ways or whether it is to be conveyed away in pipes. He speaks of "just a little fog," and is content to leave the subject in that condition.

Mr. Greenwell said: There are one or two points which deserve a little observation. I am quite, in my own mind, satisfied with the very satisfactory way in which Mr. Hall has dealt with the question of pipes. The question was brought forward in the year 1844 by Messrs. Lyell and Faraday, on the occasion of their being appointed as commissioners to examine into the accident which took place at Haswell Colliery in that year; and I think the answer that was given was pretty much the same as that given by Mr. Hall—one which at any rate to my mind, and I fancy to the minds of most gentlemen who are practical miners, was tolerably conclusive. Another point mentioned is that of

the destruction of fire-damp by the introduction of quick-lime. Now, it occurs to me that the effect of that would be the abstraction from the explosive atmosphere not of the fire-damp in any way, but of the carbonic acid gas, which has the very effect, when mixed with fire-damp, of lessening its explosiveness; therefore, I think that that proposal of Mr. Plimsoll's would do much more harm than good. With respect to the lighting of mines by electricity, the electric light is at present, no doubt, in its infancy, and we shall find modes of applying that light in the future with which we are now unacquainted. We have got certain principles laid down which no doubt we shall be able to work out, or to see worked out, in the future. One day when in Newcastle I called upon Mr. Swan, and had some conversation with him upon the question of mine lighting by means of electric lamps. I told him it was a subject I knew nothing about, and he said that I was the very person to speak to on the subject. I asked him what powers of lighting he could get out of one man. He said he thought from 25 to 50 candles per man power; and I told him that we did not want either 25 or 50 candles in a working place, but that I thought if we could get a safe light to the extent of one or two candles we should be very well satisfied. I asked him also whether he thought it would be possible, by means of clock work, giving an occasional winding up to a machine which should be portable and self-contained, to get electricity applied to the lighting of a single working place; and he said he thought the subject was well worth considering. I mention this in the presence of these gentlemen because I know that there are many among them who will give the subject their thought. There are other ways of doing it as well as by clock work; there is compressed air—that might be applied to a portable lamp in order to keep the light worked by means of this force. I with great respect make that suggestion to the gentlemen present.

The CHAIRMAN: One of the main points which Mr. Plimsoll seems to have made is the tapping and drawing off of gas from the rise. I should like to hear from gentlemen present their opinions as to the practicability of that. It is merely a matter of expense, no doubt. This has been devised, I think—or it has been advocated—for 40 years, but I have never known a case where it has been adopted.

Mr. DICKINSON: There are one or two points upon which I would wish to make an observation. It is some months ago since I read Mr. Plimsoll's paper, and if my memory serves me right, he proposed that having got the gas secured in some hole in the roof, it might be let out by a bore-hole sunk from the surface. That is by no means a new proposal. You will find it mentioned by the late Mr. Mather, of South Shields, the author of an excellent work on mining (the South Shields Report), in evidence given before a Select Committee of the House of Commons in 1852. It was suggested to him that, instead of this bore-hole casting up by the gravity of the gas, the power of the furnace or other ventilating apparatus would draw the gas not only down the bore-hole, but also from the goaf into the workings, by giving an access behind which had not previously existed. There is one other point. I have just been reading the Report of the Belgian Royal Commission on Explosions of Fire-damp, which goes into the subject for 59 years back, giving the causes of the accumulation of explosive mixtures, and also the cause of what they call the "inflammation," or the lighting. In the last 59 years, commencing with and including 1821, to the year 1879, they had in the Belgian coal mines 412 fatal explosions of fire-damp. Of these, no less than 120 were by the employment of powder. Now, that is a very important proportion. Therefore, when Mr. Plimsoll says we want a more delicate means of testing for fire-damp than we have in the safety-lamp, he only says what

I think must be considered of great importance by practical men. We know that, with about 2 per cent. of fire-damp, the air when mixed with dust becomes explosive, and as many explosions are accelerated by the compression of the mixture by a blown-out shot, some test—something which would indicate before the cap begins to show in the lamp—is of importance. There are, besides others, the test invented by Professor Forbes and Dr. Angus Smith; and there is a Scotch lamp which begins to sing as soon as there is a certain mixture of fire-damp; but we should hope that there may ultimately be found some way of getting a more delicate test which seems to be essential.

Mr. Clegg Livesey said there was one remark of the Chairman's which he thought ought not to go unchallenged: it was that this was simply a matter of expense. He would not like it to go forth that that was the opinion they held, because he believed, himself, that any arrangement in a coal mine which was liable to serious derangement was in itself a source of danger. With the lifting of the floor, the breaking of joints, the possible filling up of the "sump-hole"—as Mr. Plimsoll called it—in the roof, which would break down the pipes, there would be a stoppage of the ventilating machinery: all these things would be a source of danger instead of a benefit—therefore instead of the question of expense coming in the question of expediency was the first thing to be considered, and his own opinion was that it would be a source of danger instead of an advantage.

The Chairman said probably he ought not to say that it was altogether a question of expense. He wanted the opinion of the practical gentlemen present, as to the efficacy of the piping, as to the expense that would be incurred, and the advantage that would result from it. He was himself out of the trade and did not presume to know how a thing of that sort could be done practically; he only knew the power of money.

Mr. SEDDON: In my opinion one of the most important disadvantages of Mr. Plimsoll's proposals to pump gas from the mine by means of pipes—and perhaps the most important, judged from a practical point of view—would be that in the case of vertical pipes in shafts used for winding and other purposes, the trickling, and in some cases more than trickling, of water down the pipes, and might be a serious obstacle to the ascension of such gas. Perhaps water going down is, for purely ventilating purposes, rather an advantage than otherwise; but for the purpose of bringing gas out of a mine I see very great difficulty indeed. As to bore-holes, sunk from the surface, to be available for the ascension of gas from a mine, perhaps there is more in that idea—at all events there is, to my mind—than in any other advanced by Mr. Plimsoll. The important difficulty there again, is that in the alluvial deposits, which for the most part prevail for some distance down, surface water is met with, and would trickle down the bore-holes—and most of us in the coal trade know that there is generally water enough in mines without sending or letting any more down.

The CHAIRMAN: If you had the holes piped you might prevent it.

Mr. SEDDON: But water might go down the outside of the pipes as well as inside.

Mr. GREENWELL: A great deal of water is found in springs in the strata and this would go down the bore-hole.

Mr. SEDDON: This question has occupied my attention in more ways than one. I am connected with a mine lying from 30 to 70 degrees from the horizontal, and the question of ventilation by means of bore-holes from the surface, near the outcrop, has occupied our constant and careful attention. We have hitherto not been able to clearly see any system whereby these bore-holes can be put down from the surface so as to avoid surface water going down. The moment we

can see the way to that being feasible, no doubt we shall adopt it, because it will give us an absolute assurance that we have no gas lodging on the higher side of the goaves.

Mr. E. LEADER WILLIAMS: There can be no question of the feasibility of getting piping water-tight through the strata down to the coal measures, speaking from my knowledge of the saliferous strata of Cheshire. There, the water above the rock salt exists in the quicksand, and runs in great quantity, and many of the brine shafts could not be pumped to advantage unless the cylinders were perfectly tight down to the rock head.

The CHAIRMAN: This should be tried experimentally. I am sure plenty of colliery proprietors would allow opportunities of putting pipes down. The question is a practical one. We have a very great respect for the opinion of scientific men: I read Sir Charles Lyell's and Professor Faraday's report; but, however great their scientific attainments—one as a geologist and the other a physicist—they were hardly the men to investigate a subject like this. I have read all the reports, but never read one so practical and useful as that of Mr. Mather to this day.

Mr. DICKINSON: It was thought of such value that the Select Committee of the House of Commons, in 1852, re-printed it.

The CHAIRMAN: I obtained it as soon as it was issued; and I have never found so much practical information in so small a space. Have you any idea, Mr. Dickinson, as to what the air loaded with coal dust, in a damp mine, would fire at? You said you thought with about two per cent. of gas in a dry mine.

Mr. DICKINSON: There seems no doubt that dryness is a considerable aggravating cause of the spread of explosions by coal-dust; but perhaps it is hadly worth while going

into that now; because I believe at the next meeting it is to be a subject of discussion.

The CHAIRMAN: It has been very much overlooked. Forty years ago people had no idea that the safety-lamp, with spilled oil and coal-dust all round it, was anything but safe. But I have never seen any experiments in a damp mine where air loaded with a small amount of dust—as there must be—would explode.

Mr. DICKINSON: I see Mr. Ansell, who proposed a porcelain chamber and bladder for testing fire-damp, died recently. That invention of his was a very ingenious toy, but it was nothing more than a toy; still it was a step in the right direction, and as we have litmus and turmeric paper for detecting acids and alkalis, I do not see why we should not light upon an equally delicate test for fire-damp.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VII. VOL. XVI. SESSION 1880-81.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 26th day of April, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOHN AITKEN, Esq., Vice-President,
in the Chair.

The following additions to the Library were laid on the table:—

Bristol Naturalists' Society: Proceedings; New Series, Part 1, Vol. III.—*From the Council.* London Geological Society: Catalogue of the Library.—*From the Council.* Midland Inst. of Engineers: Transactions; Part 52, Vol. VII.—*From the Council.* Mining Inst. of Scotland: Transactions; Part 11, Vol. II.—*From the Council.* North of England Inst. of Mining and Mechanical Engineers: Transactions; Part 2, Vol. XXX.—*From the Council.* Royal Society of Edinburgh: Proceedings; Nos. 105-7, Vol. X.; 1879-80.—*From the Society.* South Wales Inst. of Engineers: Proceedings; No. 4, Vol. XII.—*From the Institute.* Annual Reports—3rd to 7th; 1874-79—on the progress of the Topographical Survey of the Adirondack Region of New York.—*From the Hon. Verplanck Colvin.* Bulletin of the U.S.A. Geological and Geographical Survey of the Territories; No. 1, Vol. VI.—*From Dr. F. V. Hayden.* Académiè Impérial de St. Petersbourg: Mémoires; VIIe Série, Nos. 5-14, Tome XXVII. Bulletin; Nos. 2 and 3, Tome XXVI.—*From the Académie.*

ON THE LONG WALL SYSTEM OF WORKING COAL.

Discussion continued.

The CHAIRMAN intimated that the paper read by Messrs. Grimshaw and Phillips on the Long Wall System was open for further discussion.

Mr. LUPTON said it appears to me that the paper is, for the most part, a statement of facts, with some legitimate deductions from those facts; that is a scientific method, and it is the method pursued by the authors of this paper. There are some statements in the paper about which I should like to ask for information. In the first part of the paper (p. 314, line nine), there is what I take to be simply a clerical error. It is said: "These and other factors would have no weight with the method ultimately adopted." I conclude that, instead of *no weight* they mean *some* weight. If not, perhaps, they will further explain their meaning. In the course of the discussion Mr. Woodward said (p. 321): "It was difficult to find packing in these thick mines which had friable roofs." I conclude that Mr. Woodward said "which had *not* friable roofs;" because when a roof breaks down it is, as a rule, easy enough to find packing. Referring to the paper again, in the second part (p. 331), the authors state that a heavy weight causes an emission of gas, and this is referred to several times. It is a statement in some respects remarkable, and if supported by sufficient evidence is of great importance; I shall, therefore, be glad to know what evidence there is of this rapid issue of gas due to the weight upon the coal. On page 332 the authors give an excellent and interesting account of the way in which a long wall mine closes tight as the working advances, but they state

incidentally that, in the case of certain dipping gate roads it would be necessary to have a scale of air down them. This would, I consider, be desirable whether the road is dipping, rising, or level. On the same page a statement by Mr. Nicholas Wood is referred to apparently indicating that there is less gas in a very deep mine than in one of moderate depth. I have myself, I think, read the statement they quote; but I have always been interested to know what evidence there was in favour of the supposition, and I shall be glad if the authors of the paper will give the evidence on which they base their statement. I am free to confess that, in the absence of strong evidence, I should doubt its correctness. There is, they say on page 333, from experiments which they have made, a sensible rise of the thermometer when there is a weight on squeezing down the packs. This is easy to believe, and is such a very interesting and important statement, that full details of the experiments would be desirable. On the same page (p. 333), they state with reference to outbursts of gas that these have occurred, they think, more frequently in long wall workings than in pillar and stall workings. There, again, I would ask for further information. Nobody, I am sure, will more readily admit than the authors of the paper that it is one thing to call workings long wall, and another thing to have them made out precisely on the pure long wall system; and I should ask them to produce plans of those mines where the outbursts have occurred to enable the meeting to decide whether the workings had, at the time of the outbursts, the characteristics of long wall workings or those of pillar and stall workings. I am, myself, acquainted with the plans of a good many mines where great outbursts of gas have taken place from the floor—mines that were said to be worked on the long wall system, and were so worked, but certainly in three of those cases the outbursts took place at a time when the state

of the mine was characteristic of a pillar and stall mine, and not a long wall mine. On p. 344—the third part of the paper—there is an interesting comparison of the different prices paid for getting coal in long wall mines. In the sixth column the heading is "Standard reduced to 1s. per ton." I fail to understand that column, and should be glad to have further information from the authors as to its meaning. On page 345 they refer to the method of banking coal in Derbyshire as compared with Lancashire; but the Derbyshire coal owners, are compelled to sort their coal. As to the cost of working, here is a most interesting statement of the costs of a long wall mine, and it is given in a most circumstantial form. Are these taken from the actual cost sheets of a colliery? Do they represent a thing that has been done, or one that might be done? I would also like to know whether the cost for overmen and supervision, ·43 of a penny, includes the salaries of manager and consulting engineer, clerks, salesmen, and others in the service; or whether wages of clerks, salesmen, and other officials connected with the colliery are included in any other portion of the costs. Also as to whether the charge for day men and odd work, 1¾d. per ton is an actual cost, and if so, I should be glad to know whether there were many faults or other difficulties in the colliery, whether taken over an average of years, months, or weeks. Then, again, with regard to banking—3½d. per ton. Does that include all the surface men? There is a previous charge of haulage and engine-men, 2·5d. I conclude these engine-men are entirely underground; but with regard to the 3·5d. for banking—that, I suppose, includes all surface wages. If so, it is remarkably cheap, because the mere sorting of the coal will often cost 3½d. in Derbyshire. With regard to the item of stores, 2d., and horse-keep, 1·13d. Does the 2d. include all stores, of every sort, including new piston-rods,

new ropes, and everything of that sort, which help to make up the adverse balance at your bank during the year. If so, whether they have any pumping at their colliery, or whether it is free from water. Such items make a difference, not only in the cost of surface wages, but also in the stores. Also, whether the charges are distributed over the sale ton or over the get ton. Does the item of 2d. for stores include fuel consumed at the works? The costs given are, I should think, in some respects, above the average; and if these costs mean the total costs of the colliery, per ton put into wagons, it is below the average; but if the figures simply stand as some items of cost, then some of them are above what you will find elsewhere, particularly the item of 2s. 4d. per ton paid to the colliers.

I think, in considering why it is that one district works long-wall and another pillar and stall, we can only arrive at a just conclusion by referring to the past history of these districts. For instance, in the Lancashire district the markets have been near at hand, as the mills, foundries, and dwelling-houses, situated almost adjoining the pit-shafts, have consumed the greater part of the coal produced; whereas in Derbyshire, if we go back to the same time, about the beginning of this century, we should find that there were very few mills, and they were situated either at a great distance from the coal mines, or were driven by water power. There were very few houses either—a very small population—and the coal to a great extent had to be transported by canals to the eastern counties, &c. That was the market for the coal, and it had to be got in such a form as would best bear the expense of transit, and would stand exposure to the weather for some months without serious deterioration. Therefore, only the hard seams were worked in Derbyshire, as large lumps as possible being required, in order to bear transit in summer time, when the canals were open, and

stacking through the autumn and winter, when the water traffic would be closed by frost, &c. It was, consequently, not a question of which method of working would be the cheapest, but which would produce the coal in the largest proportion of lumps and most suitable for the market. In Lancashire, close to the collieries, slack would have a ready sale, and the householders consumed the small percentage of large coal that remained over; so that in Lancashire the question was one of cost of production rather than proportion of lumps, and so they began with the pillar and stall system, which, I think, nobody can deny is the most obvious and easy way of getting coal.

When people come to consider how far, by some application of science, they can improve the method of getting coal, they are met at the outset by the habits of the workmen, which were formed at some previous period, and most people are aware that to change the system of working involves expense. It is curious how comparatively little the actual work to be done has, in many cases, to do with the price you pay for it. It is easy enough if you can get men in the right humour to get the work done for 25 per cent. less than the price they will demand in another humour; so that if the pillar and stall method in some cases involves more work (though I do not say that it does) than the long-wall system per ton of coal got, still it is possible you might get the coal out of the pit cheaper by the method to which the men were accustomed than any other. I know of a pit where the colliers were paid 1s. 2d. per ton for getting coal on the pillar and stall method; no yardage; seam about 5 feet thick, with a good roof and floor. It is impossible to improve on that, I think, as regards cost. In such a case as this it is ridiculous to attempt to introduce the long-wall into the pit on the ground of economy. With regard to Derbyshire, the coal that had to be produced

for the market being very hard, the cost of driving a heading, or cut through, is excessive. The product from the heading was not regarded as coal, it was called "heading stuff," and was sent to the fire hole of the colliery. This being so and the cost very great, the pillar and stall method could not be applied with advantage in these seams. The long-wall system has been since pursued even in working soft coal. But there are districts where there has been what some enthusiasts might call a retrogade movement, where, after trying the long-wall method—which, as I have pointed out, the men inherited—the proprietors have returned to some modification of the pillar and stall system. I know of one case where the seam was very thick, where, after working on the long-wall system for years—indeed, for generations—they tried heading out to the boundary and working back; the result was that under their circumstances, especially as regards underground fires, &c., they preferred the latter system. There is now in Lancashire a good outside demand for large coal owing to transport facilities, and owners have so modified their working as to produce that for which there is a demand. That is, no doubt, one of the principal reasons for the introduction of the long-wall system into this county. I take it that it is admitted on all hands that the long-wall system does produce more large coal than any other system. As to the comparative cost of the long-wall and other methods, I do not think that any argument can be found in favour of long-wall on the ground that it costs less. I think in a great number of cases it costs more than pillar and stall working, if you take the cost on the total production of coal and slack. I may mention another reason why the long-wall system has been more pursued in Derbyshire and Nottinghamshire than in this and some other districts: that is, that this district is favoured with a number of seams of

coal which compare favourably in thickness, quality of coal roof, &c., with those of Derbyshire; so that the Derbyshire people have had to pursue their work under greater difficulties than has been the case in the Wigan district, for instance, necessitating all the more care in the working details. As to the comparative safety of long-wall and pillar and stall methods, and the remarkable statement in Mr. Thomas Evans's report which is referred to—a statement which some people think is not altogether justified by the facts. Well, I think Mr. Evans made that statement after considerable experience in several districts, and it is supported by a vast weight of evidence. There can, to my mind, be no doubt that the system of long-wall working, wherever the circumstances are adapted to it—that is, pure long-wall—is much safer than the pillar and stall system, if you regard the question of liability to explosions. I will not go into the question of falls of roof and stone, because there is not time for all those questions. The long-wall system has the great advantage over the other system in vogue by the drawing road being maintained through the goaf; so that there is no part of the mine which is not crossed and re-crossed by a series of roads along which pass currents of air, which prevent the formation of any great quantity of explosive gas. In such a mine there is comparatively little room for large accumulation of fire-damp. The only explosion I remember in Mr. Evans's district within the last 15 years, where more than one or two men were killed, was where the air was passed through the whole of one pit without a single split, and 400 men were employed with only 20,000 feet of air. Except in such cases a serious explosion, involving a great sacrifice of life, is very unlikely, unless through a sudden outburst of gas which would overpower any system of ventilation. That, I say, is owing to the roads being through the gob. It must, however,

be borne in mind that the long-wall system has dangers of its own, as evidenced by the explosions in South Wales; no doubt at some of these collieries the amount of gas given off was exceedingly large, but at others, no doubt, there was a false sense of security that would hardly have been experienced in working by any other system, which led to an absence of those precautions that might otherwise have been taken. Where, as in a pillar and stall mine, you head out and leave an unventilated gob in a fiery seam, you are almost sure to create a huge gas holder, the explosion of which would destroy everybody in the pit if once the train which may communicate from that gas holder to some working place is fired. It may be said that the experience of Durham proves that the pillar and stall working is as safe as any other. There I join issue: it is true the pillar and stall system is worked with remarkable freedom from explosions in Durham and Northumberland; but I regard that simply as an evidence of how human skill and energy can make a mine safe under adverse circumstances. There is no doubt the North of England is a place where thorough discipline and skilled management were first developed, and where men were trained with greater rigour than in other parts of the country. That I consider is the cause, to a large extent, of the freedom in the North of England, and Durham in particular, from explosions; because, as you come further south, you find many explosions recorded,—not so much in recent years as fifteen years ago—all worked on this system of driving headings into some unexplored seam which contained gas in vast quantities—driving their headings faster than good currents of air could be kept up to ventilate them. The explosions were simply owing to the method of working adopted, whereas the same skill and intelligence, if it had been employed in working long-wall, would have made the

mine quite safe. Still, any mine may be safe on any system, if only the safety lamps are good and the discipline is sufficiently strict, but if we do compare the systems of working at all it is fair to point out the superiority of the long-wall system. In getting 500 tons of coal per day from narrow headings, the workings must extend over and drain an extent of ground very much greater than in getting the same tonnage by long wall. By holing sufficiently under the coal, the use of gunpowder becomes unnecessary in long-wall workings. The reason why in a long-wall mine cavities for the accumulation of gas do not exist, is that, owing to the entire removal of all pillars the surface subsides and the strata completely close any cavity which is not filled up with packing.

Mr. PHILLIPS, in reply, said that his remarks would refer to the discussion which took place at the meeting in Wigan, last February. And that he would reserve his replies to the last speaker to some future occasion.

Nearly all the speakers had said something favourable of the long-wall system, but there are several details on which some explanation appears desirable.

It is not claimed that the system is perfect, or that its adoption implies total immunity from accident. That happy desideratum supposes a perfection of natural and artificial conditions which unfortunately neither collieries nor humanity possesses. What is sought by such discussions as the present, and by such systems and modifications of systems as are being now and then adopted, and more or less successfully worked, is to attain by deliberation and experiment a conception of that system of working, which, under good discipline and management, shall have the nearest possible approach to perfection.

When that system of working coal has been applied which is best adapted to the natural advantages and disad-

vantages with which it has to deal, there remains another essential to entire exemption from accident, that is, an infallible instinct to avoid the thousand hidden and threatening dangers which surround the miner in his daily avocation. The only substitutes for this instinct are an increase in the standard of general intelligence and keen all-round discipline.

And it may be said of discipline, that an inferior system of working coal well officered and regulated, may in the number of accidents be favourably compared with a better system badly managed. But allow the two systems to be applied to the same natural conditions, and to be equally well disciplined, then the balance must remain to the credit of the better system. A strong well-built ship has sometimes been lost by faulty navigation ; another with timbers half rotten, and in a leaky and almost sinking condition, has, by skilled sailing, been brought safely to port.

The west of England appears to be in a state of transition from a system of working coal by piecemeal to one of simple wholesale clearance. The latter principle, if I rightly interpret the sense of this discussion, is approved, and the experimental stage seems to be well advanced. The only difficulties now appear to be in minor detail. Mr. Hedley's criticisms may be summed up as generally favourable, and he has had experience of various systems.

Those of Mr. Longbotham being somewhat adverse, call for more notice. He points out an apparent error in dating the extract from Mr. Evans' report at page 314, Vol. XV., for 1879. He will find that year the correct one, although the opinion embodied in the excerpt may have been written in 1880 But the year does not affect either the value or validity of the authority quoted.

Mr. Longbotham is also of opinion that there is greater danger in firing shots in the long-wall than in the board

and pillar system. There is danger in shot firing anywhere. It is, however, with comparisons we have to deal. And a true comparison must be made, under exactly similar natural conditions, before a just conclusion can be drawn.

One consideration is not touched upon in his remarks. That is the fact that under the long-wall system the necessity for blasting is reduced to a minimum. Gravity is a much better coal winner than powder; and with intelligent workmen and fair conducive conditions, hundreds of tons of coal may be wrought without a shot. Several collieries could be mentioned where a shot per month in blasting down coal is exceptional. At these very collieries, on any other system, blasting on a large scale would be the rule.

It will probably be admitted that the seams in the West of England are easier wrought than those in the Midlands. It may also be assumed that the skill and carefulness of miners in using powder does not differ much throughout England. Yet it will be found, on reference to the Mining Inspectors' Reports for 1877, 1878, and 1879, that 10,095,053 tons were wrought per life lost by blasting in the Midlands, against 8,710,588 tons in North and East Lancashire, and 6,592,230 tons in West Lancashire and North Wales. Singularly enough, the number of lives lost by blasting was four in each district in the three years. During the three years, 37,640 persons were employed per life lost in blasting in the Midlands; in West Lancashire and North Wales, 29,706; and in North and East Lancashire, 22,472.

But let the matter be examined a little closer. It is stated to be more dangerous to fire shots into a goaf than into a bord.

Consulting the Blue Books again, for the same years, it will be found that the relative number of tons wrought per life lost from explosions, was immensely in favour of the Midlands as against the two districts above mentioned. Those comparative statistics give an approximate ratio of the

risk attending blasting in each system. It may be said that seams in the two West districts are much more active in generating gas than those in the Midlands. Before that argument can have weight, it must be shown that under the post and pillar system the Midland seams would be as ungenerative as they apparently are now. Experienced engineers give it as their opinion that the post and pillar system of working, if introduced to the Midland county seams, would also introduce risks from gas generation which at present are unknown.

One great advantage of the long-wall system is that the source of gas generation is exposed to the sweep of the air-current. The goaves may form storage room for gas, but under a proper mode of ventilating them, no gas should find lodging there. If the working face is on the rise, the gas will ascend from the goaf into the air-current. If the faces are on the "dip," the gas should be allowed to filter into the gateways—or be winded from them.

I pass now to another objection made by Mr. Longbotham to the long-wall system, that is by reason of the supposed greater number of accidents from falls of roof. Mr. Longbotham would, perhaps, have been more logically consistent if he had limited his comparisons to the western districts. Not that the Midland long-wall system has anything to fear by comparison with the northern coal fields. I may just say, in parenthesis, that for the past year or two there has been a greater number of persons employed per life lost in the Midlands than in any other district.

Returning to the comparative number of accidents by falls of roof. In this, as in other instances of comparison, we are met by our ignorance of natural conditions in the two cases. To obtain a just inference the cohesion of the strata must be the same in the districts under consideration; the supervision must also be equally exacting. As we cannot have these data, we must proceed on the assumption that the

roof of the three districts about to be compared are about the same degree of goodness. In this comparison it must also be remembered that every person employed in a mine is liable to accident from falling roof. A good general comparison may, therefore, be made by comparing the number of persons employed per life lost.

For the years 1877, 1878, and 1879 the comparison comes out as follows:—

District.	1877. Persons employed per lives lost.	1878. Persons employed per lives lost.	1879. Persons employed per lives lost.	Average of 3 years.
Midlands	1676	1592	1958	1741
West Lancashire and North Wales.	858	722	839	806
North and East Lancashire	1397	902	922	1097

But this comparison may be carried into Mr. Longbotham's own field of argument, that is, the two northern districts. For the years, as above, the result is as follows:—

District.	1877. Persons employed per lives lost.	1878. Persons employed per lives lost.	1879. Persons employed per lives lost.	Average of 3 years.
Midlands	1676	1592	1958	1741
North Durham	1500	1418	1994	1637
South Durham	1525	1429	1709	1554

It may not be undeserving of note to point out again that the proper basis of comparison in the matter is not the number of tons wrought per life lost, but the number of persons liable to the class of accidents under consideration.

Proceeding to the question of cost, it has not been attempted to supply every item of cost. Such as have been given may be made use of in applying comparatively to analagous items under other systems.

At page 98, Parts IV. and V., Vol. XVI., Mr. Longbotham makes use of a curious argument. Quoting statistics showing that the get per man in the Midlands is less than in several other districts, he infers that therefore "the work performed per man employed is less." When the difference

in getting facility between the Midland seams and those of the west is considered, the wonder to me is that the difference is not greater, and I do not think it rash to opine that as the long-wall system of coal getting is more generally applied in the west of England, the get per head will be still higher. If Mr. Longbotham's argument discloses anything, it is the inference that, with a heavy charter on coal getting as compared with this side of England, the long-wall method is more economical in other departments of cost.

The table of gets per man reduced to 1s. per ton at page 344 will enable members to compare the instances there given with those within their own immediate experience. A glance at that table will show that whatever the charter per ton may be, the miner has about the same amount of work to do for a day's wages.

Mr. Gilroy made reference to the practice of packing by a distinct set of men to those engaged in working coal. Such a practice must entail risks and costs which under a system of combining all kinds of work under one set of stallmen, would be avoided.

Mr. Martin's observations touch upon a matter which has almost entirely been lost sight of by writers on ventilation. I mean the influence of gradient on friction. It is well known that dip workings are much more easily ventilated than those on the rise, unless the exit in the latter case be ascentional.

Where fresh air has to be propelled to the rise, it is probable that the power required is based on the principle of that applied to the propulsion of all rising bodies. The heavier the gradient, therefore, the greater the power required. Another disadvantage accompanying this mode of ventilation is the extra propelling power requisite to force air of an elevated temperature downwards.

The discussion was then further adjourned.

EXTINCT VOLCANOES OF AUVERGNE, FRANCE.

By W. J. Black, F.R.C.S.E.. F.G S., Ed.

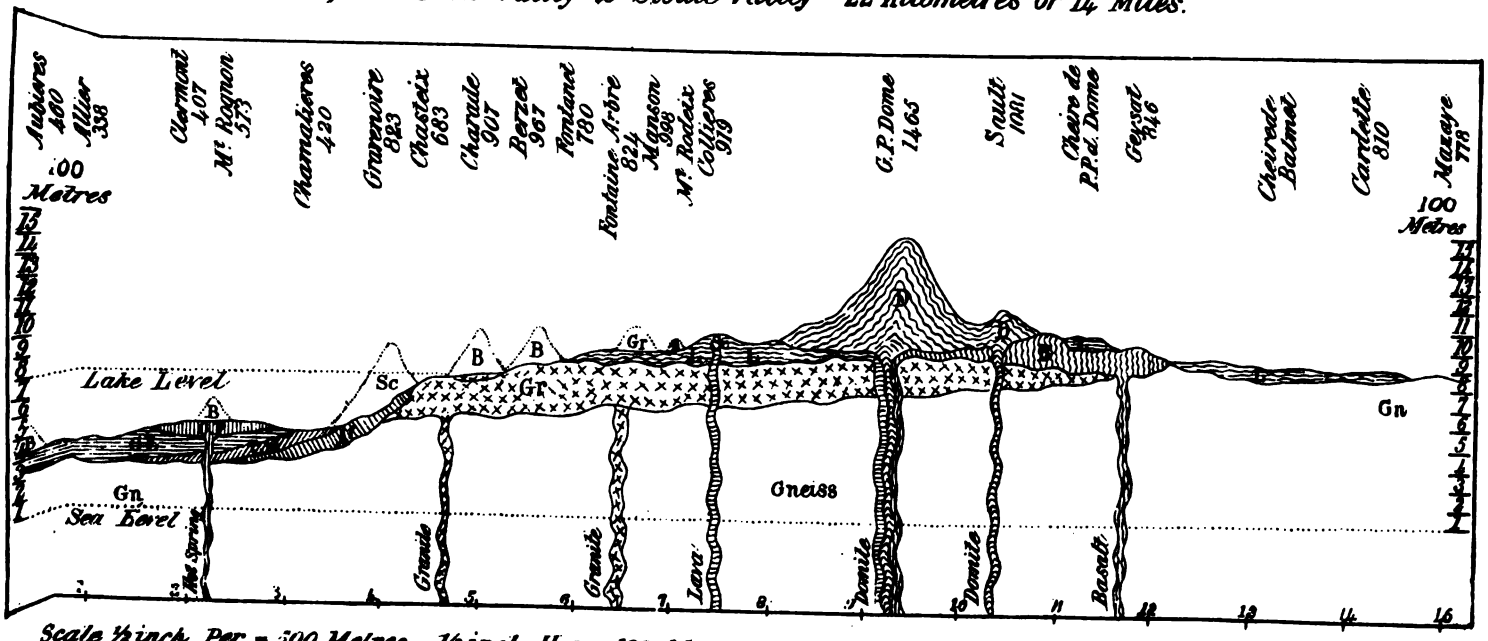
Mr. Black exhibited an interesting series of minerals from the volcanic district of Auvergne, and explained at some length their nature, and the sources from whence they were derived. He described also the physical features of the country, and its extreme interest from a geological point of view, and communicated the following observations:—

He gave a short account of a visit to the extinct *volcanoes of Auvergne*, France, and illustrated it by diagrams of the geology of the Monts Dome, sections of the mountain chains, and photographs and sketches of the localities. The character of the chief volcanic formations were explained by numerous minerals gathered on the spot, which consisted chiefly of granites, basalts, domites, lavas and scoriæ, and some lead and arsenic ores, and lacustrine formations. The transition was traced from the older basalts of the solid columnar form, through the more modern vesicular kinds, up to the newer blue lavas and scoriæ, where the steam vapour more and more seemed to enter into the production of their structure.

The Trachytes in this region are represented chiefly by the Domites, a whitish pumiceous rock, and found only on five of the volcanoes out of sixty of all sorts belonging to the chain of the Monts Dome, as on the Grand Puy Dome, and Suchet. The date of the eruption of these domites is still a matter of controversy, but he was inclined to place some of it between the older basalts and the modern lavas and others after the latter, as in the cases of Sarcouy and Cliersou.

GEOLOGICAL SECTION - CLERMONT and PUY de DOME. AUVERGNE. FRANCE. East to West

from Allier Valley to Sioule Valley - 22 Kilometres or 14 Miles.



Scale ½ inch Per - 500 Metres - 3½ inch Hor - 1380 Metres

C.P. *Calcaire Piperino* - C.L. *Calcaire Lacustre* - C.M. *Calcaire Marneux* - Ar. *Arkoses Grits* - D. *Domite*

Sc. *Scoriæ* - L. *Lava* - B. *Basalt* - Gr *Granite* - Gn. *Gneiss. Schists. Slates.*

He endeavoured to show that the granites lying on the elevated plateau on which the Monts Dome are erected, should be considered an eruptive bed also, lying between the Gneiss and Mica Schists below and the solid basalts above.*

It would be difficult to account for the course of the vents of some of the Volcanoes on the Plateau, as those of Nugère and Louchadière and others, if there were no other strata below them, but the solid granite as a basis of eruption.

The Gneissic formations are the lowest strata composing the Auvergne Highlands, and seem to form the bases of the Monts Dome and Monts Forez chains running through them. Between these two ranges lies the lake basin of the Allier Valley, with well defined margins east and west, and the river running through it from S. to N., and this part of it extends from Brioude to Gannat S. to N., and Clermont to Thiers W. to E. This basin was hollowed out of the Gneiss and Schists, but is now filled up with 3 or 4 lacustrine deposits, viz.: at the sides *arkose grits, calcaire marneux*, and *calcaire lacustre* in the basin, with *alluvion moderne, and oolitic piperino*, in patches on the surface, and was probably about 300 to 400 metres deep.

The first bed is inclined and rough and gritty, like millstone grit, the next two are horizontal and fine grained, like sandstones and shales, and the last pisolithic and

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*TEXT BOOK OF GEOLOGY. 6th Edition. D. PAGE.

Igneous Rocks, p. 124. 1. Granitic. 2 Trappean. 3. Volcanic.

P. 126.—The great epoch of granitic intensity being that, which terminated with the deposition of the Silurian strata.

P. 127.—As an igneous rock, granite occurs either in *eruptive* mountain masses, in dykes, or in veins.

The logical inference from the whole of this chapter seems inevitable, though it is not hardly stated, that granite is as much an *eruptive* rock as basalt and behaves itself in like way under similar conditions.

coarse, like travertine, and all are more or less sandy or argillaceous in different proportions, and mixed with lime.

It should be mentioned that there are no secondary strata as red-sand stones or lime-stones lying on the Auvergne plateau in regular beds, (perhaps they never were formed), so that the Granite and Gneiss are quite bare, and only patches here and there of carboniferous formations in the Valleys are to be met with.

He believed that these Lacustrine formations were derived first from the denudation of the Gneissic surfaces on each side, and then of the granite beds, and lastly of the basaltic layers, but scarcely from the modern blue lavas. The upper ones are considered by the French as of Tertiary or Quaternary age, or oligocene, miocene, and pliocene beds by other geologists, containing Cypris shells and Phryganea cases in great quantities.

It was likely that the later volcanoes continued active during the time they were supplied with water by the lake basin of the Allier close at hand, through fissures in its banks, when it was full. They ceased to emit probably when the lake was emptied, at the end of the glacial epoch, by the torrent of the melted snows bursting the barrier near Sancaisse.*

These volcanoes were of various kinds, and had different

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*MANUAL OF GEOLOGY.—SIR CHARLES LYELL. 5th Edition.

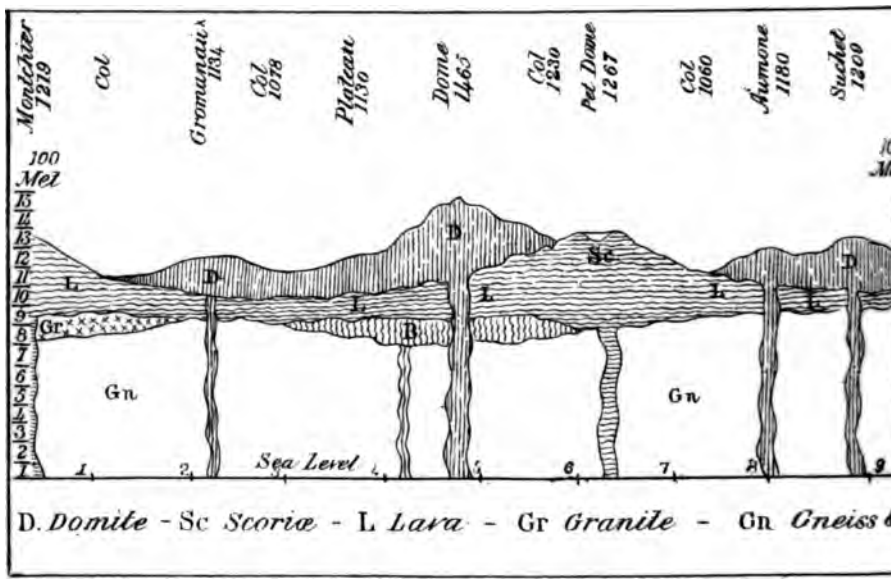
P. 558.—At Pont du Chateau, near Clermont, a precipice is seen on the banks of the Allier river, where beds of *volcanic tuff* alternate with fresh water limestone, spotted with fragments of volcanic matter matter, deposited while showers of sand and *scoriæ* were projected from a neighbouring vent (Gravenoire).

P. 559.—In the Puy de Marmont, near Veyres, in the valley of the Momme, a fresh water marl alternates with *volcanic tuff* containing eocene shells.

The position and contents of some of the associated tuffs prove them to have been derived from volcanic eruptions, which occurred *during the deposition* of the Lacustrine strata.

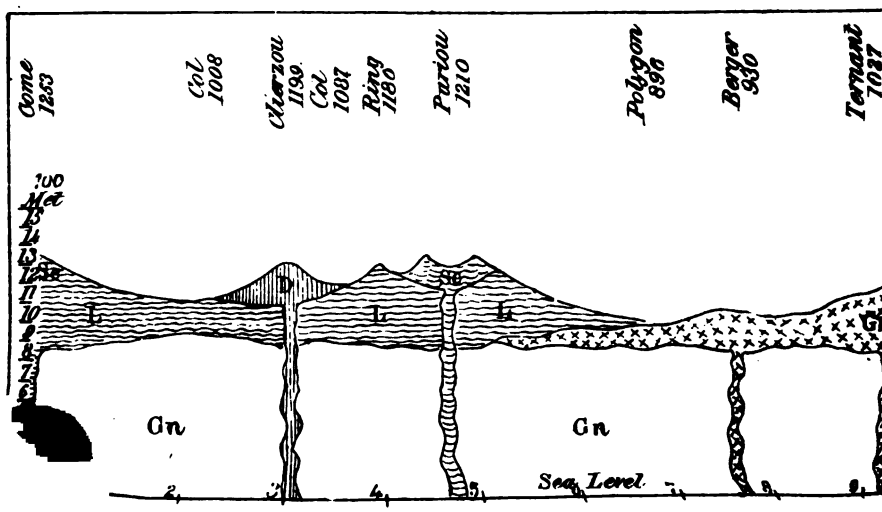
GEOLOGICAL SECTION – Grand PUY de DOME.

South to North – *5 Kilometres – 3¼ Miles – Scale Natural.*



GEOLOGICAL SECTION – PUY de PARIOU.

West to East *5 Kilometres – 3¼ Miles – Scale Natural.*



origins or vents, and had different *cheires* or streams flowing from them; and it was difficult to surmise why one volcano should throw out basalt, another domite, and another blue lava, when they were all seated on the same plateau.

The later ones, as Nugère and Gravenoire, are of conocrateral formation, like Vesuvius, and some of these had perfect cupshaped craters, as Pariou, and others only half ones, as the Vache, and some had double ones, as Come.

This form is here probably due to the introduction of steam in the method of their erection, which was not the active agent in the next and older series of eruptions, when compression was brought into action to extrude the hot fluid rock, from the subjacent regions.

The other volcanoes, again, were dome-shaped and had no craters nor streams, as the domitic ones of Sarcouy and Cliersou; and the basaltic ones as of Montrognon and Gergovia, were peaked or table-topped, and these were called *points d'eruptives* by the French, and the oldest still, the granitic, were simply mounds or lumps of solidified molten rock, as Orcines and Font du Berger, and Manson.

The lava streams from these volcanoes were composed of first, the solid columnar basalt running down the valleys eroded out of the granite, on the east to the Allier Valley, as from Charade, and in the Gneiss to the west, to the Sioule Valley, as those from Sault. Then there were the vescicular basalts of Pariou coming next, and lastly, the blue lavas of Volvic and Royat, and over all the loose scoriæ and cinders, as from the Petit Puy de Dome. Attention was wished to be directed to inserting in the geological diagrams, the theoretic course of volcanic vents in the inferior strata, in cases of eruptive points of the volcanic rock showing on the surface of the earth. These were often omitted, as in the French diagrams, from which it might be inferred that these masses were due to the lateral extension of single

or several beds horizontally from distant points at the highest elevation, instead of ascending directly from below, perpendicularly upwards.

The glacial epochs seem to have affected this district, as there are remains of transported boulders and rolled pebbles scattered all over the Allier Valley derived from the Highlands above on the east and west.* Claremont itself is probably built upon a mound of *oolitic travertine*, situated at the mouths of the affluents of the Tiretaine, opening on the valley of Chamalieres, and derived from hot springs from the floor of the Valley beneath it, bubbling up and incrusting. The later lavas of Pariou, and Come, and Petit Dome do not seem to have been subjected to much denudation, as their surfaces are still rough with scoriæ, as those of Vesuvius. Some of these volcanic rocks are utilised for building purposes, as the blue lavas of Volvic, and Royat, and the domites of Clierzou and Sarcouy, where quarries have been worked since Roman times; and the arkose rocks are used also, as seen at Royat. The district abounds in mineral springs, as those at Royat, Chatelguyón, Chateauneuf, &c., which are highly charged with mineral constituents, derived from the solution of the softened Granitic and Gneissic rocks, and the calcareous beds as at St. Alyre. An extensive industry in the making of Petrifactions by these waters is carried on in Auvergne, and objects of art are produced, as medallions and statuettes, which are superior to anything produced in Britain by the same agency.

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*MANUAL OF GEOLOGY.—Sir Charles Lyell. 5th Edition.

P. 198–199.—The strata (arkoses) on the confines of the Lacustrine Basin contain pebbles of all the ancient works of the adjoining elevated country, as granite, *Gneiss*, *Micaschist*, clay-slate, and others, without any intermixture of basaltic or tertiary volcanic rocks. At Chamalieres, near Clermont, in the valley, pebbles are seen to consist of rounded and angular fragments of granite, quartz, *primary slate*, and red sandstone.

Concerning the metallic ores found in this region, the lead is got out of the Gneiss and Schist, as at Pont Gibaud, the arsenic out of the Lavas and it therefore appears in the Mineral Springs.

The CHAIRMAN said that he was much interested in Mr. Black's account of the district of Auvergne, but objected to the effect ascribed to the melting of ice at the termination of the glacial epoch, viz., the cessation of volcanic action.

Professor DAWKINS said that he could not agree with all that Mr. Black had stated with reference either to the volcanic phenomena, or those of a later date. It was, of course, far too late, that afternoon, to discuss either one or the other; he would only say that Mr. Black's views were directly opposed to those advanced by Mr. Scrope, who spent so much time in working up this subject. He (Professor Dawkins) also failed to recognise in the paper any reference to the work done by Sir Charles Lyell. To mention one cardinal point: he could hardly accept the statement that granite was a stratified rock, or that it was an erupted rock. Those two things it would take a great deal of proof to induce him to accept. Further, with regard to Mr. Black's vertical sections—he could not accept the fact that the gneiss was distinctly below the granite, as represented in those sections. He had not spent a sufficient length of time in the Auvergne district to communicate anything to the Society which would be of value, but he certainly did look upon granite—as Sir C. Lyell and all other geologists did who had examined that district—as a fundamental rock, a rock not formed near the surface; and he believed that the granitic plateau, on which the volcanoes were perched, had no relation to the volcanoes themselves.

Mr. MARK STIRRUP said that, having paid a visit to Auvergne, with Professor Dawkins, he was very much interested in the subject of the paper. It was a district

which, to all geologists, was classic ground. Whilst thanking Mr. Black for his interesting paper, there were many of his statements which he could not, any more than Professor Dawkins, agree with. The older lacustrine strata were, he believed, deposited long before the action of the volcanoes commenced, and he thought there was sufficient proof of that in the lower strata of which Mr. Black had spoken, and of which there were three or four well defined and thick beds, and in which there was not an atom of volcanic rock to be seen. The strata were formed not of volcanic rock, but from the wearing down of the granite rocks which were there. Did it stand to reason that if the volcanoes had been in active operation at the time when the lacustrine strata were deposited, we should not have had specimens of the volcanic rocks in those strata? There were not there: therefore the conclusions arrived at by Mr. Scrope and the old geologists were to be regarded as unshaken.

Mr. Black, in reply, said that his views on the geological position of granite were suggested to him some time since from observations in other places abroad, where he had seen it in hummocky forms and cake-like beds, superposed upon secondary strata, as well as primary. It would be anticipated, again, to find volcanic scoria and ashes in the beds of the lacustrine strata of the Allier Valley, as these would not probably have been all decomposed by water into sand, and lime, and clay before their arrival at the lake, especially from the craters lying nearest to them.

The Lava streams from Gravenoire, Jumes, and Nugère, however, are to be seen invading the levels of the Allier Valley, and lying on the beds of the Calcaire Lacustre, thus testifying to their flowing when the latter were laid down in this fresh water lake.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VIII. VOL. XVI. SESSION 1880-81.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 31st day of May, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOHN E. FORBES, Esq., F.G.S., Vice-President, in the Chair.

The following additions to the Library were laid on the table:—

Cambridge University: Report of the Museum and Lecture Rooms' Syndicate for 1880.—*From Prof. Hughes.* Devon and Exeter Free Library: 11th Annual Report.—*From the Committee.* "Geological Magazine:" April, May, and June, 1881.—*Purchased.* Geologists' Association: Proceedings; No. 1, Vol. VII.—*From the Council.* Institute of Mechanical Engineers: Proceedings, No. 1, 1881; and Library Catalogue.—*From the Council.* Manchester Field Naturalists and Archæologists' Society: Report and Proceedings for 1880.—*From the Society.* Manchester Scientific Students' Association: Catalogue of the Library.—*From the Council.* Midland Institute of Engineers: Transactions; Part 53, Vol. VII.—*From the Council.* Mining Institute of Scotland: Transactions; Parts 1 and 2, Vol. III.; and Rules.—*From the Council.* Royal Geological Society of Cornwall: Transactions; Parts 1, 2, and 3, Vol. X.—*From the Council.* Victoria: Reports of Mining Surveyors and Registrars for Quarter ending 31st December, 1880. Pamphlet: "The Post-Tertiary Geology of Cornwall;" by W. A. E. USSHER.—*From the Author.* Pamphlet: "Information for

Emigrants, 1881."—*From the Kentucky Geological Survey.* Museum of Comparative Zoology, Cambridge, U.S.A.: Bulletin; No. 4, Vol. VIII.—*From Prof. Agassiz.* Deutschen Geologischen Gesellschaft: Zeitschrift; Heft 4, Band XXXII.—*From the Society.* Sociéte Royale Malacologique de Belgique; Annales, Tome XII.; et Procès Verbaux des Séansces, Janvier, 1879,—Septembre, 1880.—*From the Society.*

Mr. W. J. Grimshaw exhibited an antiquated Spring Hook and an old Powder Horn, which he said were found, at a depth of 80 yards, in old workings of a lead mine with which he was connected in North Wales. He was unable to say what date they belonged to.

ON THE GLACIAL GEOLOGY OF THE DISTRICT OF LLANDUDNO, WITH ESPECIAL REFERENCE TO THE BOULDER CLAYS.

By Mark Stirrup, F.G.S.

The pleasant watering-place of Llandudno is doubtless well known to most of you, and its glacial phenomena, such as the contour of its hills and its drift deposits, can scarcely have escaped the eye of the geological visitor.

The particular sections of one or two of these drift deposits, to which I shall draw your attention, have come under the notice of several geologists at various times, and their remarks thereon may be found in the pages of the *Geological Magazine* and elsewhere.

Differing from some of these writers in the reading of these sections and their deductions, I have ventured to bring the result of my examination of them before you, with a hope that it may add some little to the knowledge already possessed.

Notwithstanding the mass of literature with which the geologist of recent years has been nigh overwhelmed on this subject of glacial geology, much yet remains to be done to clear up the doubts and the difficulties with which the topic bristles.

Yet, among many unsolved problems, nothing stands out more clearly than the well established truth that Great Britain, alike with the northern part of our hemisphere, was subjected, at a period geologically recent, to a climate infinitely ruder and more arctic than that she possesses now. The continued operation of this extreme cold has left its impress on the rocks, and covered with their *débris* the low lying lands with those masses of clay, sand, and stones, known as the drift or glacial deposits, which may be so conveniently studied in this portion of North Wales.

Into the question whether the drift deposits be due to *land* or *marine* ice, I do not intend to enter further than the special sections under review may demonstrate; nor is it my purpose to traverse those wider fields of enquiry which have for their object the explanation of the cause of the climatic change, which resulted in what is now generally known as the "Great Ice Age."

These subjects, so tempting for discussion, would probably be out of place here; so I must necessarily limit myself to the drier details of the section before you, the right understanding of which may guide us in our decision on these moot points.

On several occasions during short visits to Llandudno, I have been struck with the extremely local aspect of the boulders found in the till, differing in that respect from the lower boulder clays of Lancashire, in which silurian rocks and granites, foreign to the neighbourhood, occur.

The principal section which has engaged my attention is one on the Conway Bay side of Llandudno, in a southerly

direction from the Great Orme, where may be seen a good exposure of the lower boulder clay or till, rising from among the low sand hills which bound the shore.

It is of no great height or extent, stretching for about 300 to 350 yards along the strand, and averaging about 25 to 30 feet in height.

It is a dark coloured, blackish clay, especially towards the bottom, getting lighter in colour, or of a darkish grey, towards the top.

It is crammed with boulders of all shapes and sizes, which are confusedly scattered through the clay.

Many of the stones are polished and striated, and some of the large boulders, which lie on the shore in front of the cliff, still retain groovings and striæ, although long exposed to the weather and the sea.* Great numbers of small pebbles of a dark blue slaty rock, *apparently water-worn*, abound in the clay, especially in the lower portion. The boulders consist principally of rocks of a siliceous character, feldspar trap, volcanic ash, and Lower Silurian rocks, probably of Bala age, some of which are calcareous.

This deposit of till abuts at the northern end against the sand-hills, and traces of the redder clay (marked No. 2 on the diagram) may be detected as it dies away under the sand.

At the southern extremity it becomes less stony, and gradually slopes away under the red clay described as No. 2.

No shells were found in it.

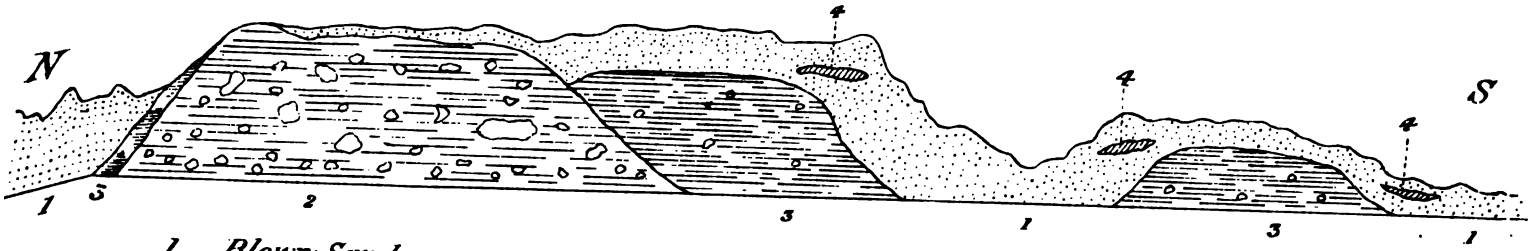
The No. 2 clay, from its position, evidently later in date than the till, is of a red colour, stiff and plastic, with very few stones in it, and those of small size. I could find no shells in it.

Walking southwards along the shore for 60 or 70 yards,

* A few of these are of such dimensions that they may be estimated to weigh 10 to 14 tons each.

CONWAY BAY SHORE AT LLANDUDNO.

Greatest height of Cliff about 30 feet.
Length of Section of Till No. 2 deposit about 300 Yds.



1. Blown Sand
2. Till
3. Reddish Clay with few Stones & those Small
4. Seams of Mytilus Edulis in Sand

N. - Pen Morfa. Great Ormes Head to North of Section. S. - Deganwy to South of Section.

this deposit of red clay disappears, and is replaced by sand (blown sand), but reappears again at about 200 yards distance, and finally disappears under low sand hills as you approach Deganwy.

This red clay does not rise to same height as the till (about 10 to 12 feet), but both clays have evidently suffered denudation before the accumulation of the sand which caps both deposits, and which lies on the somewhat horizontally planed surfaces of the clay.

This sand, which I take to be æolian or blown sand, lies but thinly on the till, especially at the northern end, where it is in some places only a few inches thick, but it increases southwards to a depth of 4 or 5 feet over the red clay, and then comes down to the shore, forming the sand hills which divide the two exposures of the red clay.

I may just mention that in this sand, about two feet or so from the surface, occur at intervals along the coast aggregations of the shells of the common mussel, *Mytilus edulis.*

These bands of shells have been noticed by previous investigators of this section, but either the cause of their appearance in this position has been left unexplained, or they have been referred to as "kitchen middens;" if by this latter statement it is meant that they are the remains of a pre-historic people, I am of opinion that a more truthful interpretation may be offered. These beds of shells, sometimes a foot or more in thickness, I take to be the result of the pearl-fisher's occupation, which, as far back as the pre-Roman times, is said to have been carried on in the neighbourhood of the estuary of the Conway.

Pearl collecting has only been discontinued within the last few years, and on Conway Marsh large banks of the mussel shells covered with sand, many feet in thickness, still remain as relics of the trade.

The practice was, after collecting the mussels, which are

found on several of the banks in the bay, to take them to a cauldron, or boiler, erected as near as possible to the mussel banks, but out of reach of high water, where they were boiled, after which the pearls were sought for, and the hells thrown in a heap around.

This occupation was chiefly left to women, and the pearls thus collected were bought by some one in the town, who acted as a sort of agent to a merchant who made periodical visits to Conway.

These beds, or layers of shells, have, in the course of time, gradually solidified and been covered with blown sand, and no doubt some of them may be of considerable antiquity.

Returning to the boulder clays of the section, you will notice the difference in structure, colour, and position, which point out a diversity of origin and a sequence of deposit.

In the examination of the older deposit or till, what puzzled me most was the absence of stones belonging to the mountain limestone, notwithstanding the vicinity of this rock, in those grand masses of the Great Orme to the north, the Little Orme to the east, and a prolongation of the same limestone ridge to the south-east, and immediately in rear of this deposit, the most distant of these outcrops not being more than two to three miles in a straight line.

This exclusion of mountain limestone boulders seemed to point to a very confined area as the birth-place or source of the stones, unless they came from the high ground on the other side of Conway Bay.

With a hope of elucidating this point, I examined Conway mountain and Penmaenbach, and although I found on the summit of Conway mountain, rocks of feldspatic trap, presenting the same structural characters as those of Deganwy hills, I came away unconvinced of this locality being the original home of the boulders.

To account for the striation of the boulders and the

rounding of the pebbles, by the movement of a glacier from the adjacent hills to the shore, seemed too much to demand of it, seeing that the distance is so short, and the area of accumulation for the ice so circumscribed; yet the evidence seems to point to no other source of the rocks included in the till, than that of the high ground to the south and south-east, all within a radius of one to two miles.

To this limited space, which includes the hills of Bryniau, Bryn Gosol, and Castell Deganwy, I have been able to trace the majority of the boulders, and have obtained specimens of the rocks, which compare structurally and mineralogically with those found in the till, samples of which lie on the table for your examination.

Their variety may be accounted for by the intrusion of plutonic rocks among the sedimentary strata, causing thereby much metamorphism.

On the summit of Bryn Gosol may be seen an interesting rock formed of large globular concretions of chert or hornstone, often of an olive green colour.

The large number of pebbles which occur in the blackish clay (many marked by faint striæ), presented another difficulty.

At first I took the pebbles to be water-worn, but it seemed scarcely possible that a stream of water circulating beneath a glacier should be able to abrade and round stones while passing over so short a space of ground, as my hypothesis demanded. This difficulty I believe has been removed by my finding the pebbles "*in situ*."

In roaming over the Castell Deganwy hills, I came across a stratum of dark blue slaty rock, in which occur nodular concretions and pebbles of a like character to those found in the clay, and which I think identical.

The blackish clay of the till is no doubt due to the grinding power of the glacier on the slaty or shaly rocks which

lie between the ridge of erupted rock and the shore, and which may be well seen near the farm of Maes-dû. The groovings and striations, which are found on some of the large blocks on the beach, may have been made while attached to the parent rock by the passage of glaciers over them, before they have been finally wedged out by arctic frosts, and carried shorewards by the glacier.

If I have read aright the evidence of this deposit of till, it would indicate a period of intense cold, with a precipitation of snow, such as to form only local glaciers on the higher lands, each little system of hills or mountains being an area of accumulation, whence moved off ice rivers or glaciers in the paths of least resistance to their march.

The question naturally arises, can this deposit be correlated with the till or boulder clay of Scotland, which Dr. Geikie says was 3000 feet thick in its deeper parts, and overspread wide tracts of country?

The evidence before us would suggest either a very sensible diminution in the arctic severity of the climate of this portion of North Wales, from that of the north of Scotland, during this phase of the "Great Ice Age," or that the deposit belongs to an entirely different period.

All the facts are in favour of a local glacier, entirely disconnected from any ice sheet or *mer de glace;* for, on any other supposition, it would be impossible to account for the absence of boulders of neighbouring rocks.

On the southern side of the Castell Deganwy hill, in a quarry overlooking the hamlet of Towyn, may be seen an illustration of the bending over or curving of the basset edges of the Bala beds of the Lower Silurian, which here seem to have been thrown into a vertical position. Where bent, the rock is broken and assumes a flaggy structure.

Occurrences of like character, in well glaciated districts, have been attributed to the pressure exerted during the passage of a glacier over the rocks.

These strata are bent over in a southerly direction; and if this rending and curvature are due to the action of ice, it would strengthen my hypothesis, by showing that the crown of the hill served as an *ice*-shed, from which glaciers moved off in more than one direction.

Another deposit of the till, on the Orme's Bay shore of Llandudno, supports the same line of argument. This section may be seen on the western or Llandudno side of the Little Orme, where it forms clay cliffs, abutting against the limestone rocks on the one side and extending westwards along the shore for some little distance towards the town.

I have not had time to examine this deposit as thoroughly as I could wish, yet a cursory inspection will demonstrate that, in this instance, the *majority* of the blocks are of *mountain limestone*, which have come from the headland of the Little Orme and the adjoining hills, whose contours are those which are well known to be induced by glaciation.

The upper part of this section consists of a reddish clay, and presumably of a later date than the underlying portion, which I take to represent the till of the Conway shore deposit.

The clay, where it is massed against the Little Orme, seems free from large boulders, which begin to abound 50 to 100 yards westwards: these are chiefly of mountain limestone, with some trap and slaty rocks.

The main stream of the glacier which has deposited this morainic matter, seems to have poured on to the shore through that conspicuous gap or gorge in the limestone along which the road to Colwyn passes.

Besides the usual boulders there are some conspicuous blocks of conglomerate, formed of limestone, other rocks, and clay, all cemented together by a solution of lime into hard masses, which have fallen out of the cliffs and now lie imposingly on the shore.

Relics of the deposit of till may be detected at other points in the district of Llandudno, for instance, on the east side of the Little Orme, on the shore, at the little village of Rhos.

I now come to the red-coloured clay, which, from its position, is certainly of more recent origin. It may be described as a very stiff, plastic clay, with very few stones in it.

It has evidently suffered great denudation, the sections on the Conway shore showing horizontally planed surfaces.

This clay covers the greater portion of the flat marsh land of the Morfa Rhianedd, which lies at the back of the town of Llandudno, but it attains a much higher elevation on the sides of the hills to the southwards, which overlook the marsh, than where it is exposed on the shore.

In a recent excavation for a tar-well at the gas-works, a stratum of solid blue clay was dug through to a depth of 14 or 15 feet; it was extremely compact, the pick having to be used in its extraction.

It is said that during the operations the workmen passed through a bed of shells (cockles and mussels), and also through a thin seam of sand.

This statement, which is a very interesting one, would imply a change to a more genial climate than that previously prevailing, and one probably of considerable duration, during which these molluscs bred and thrived in the waters which then covered this flat land, until the return of glacial conditions overwhelmed and buried them in the clay where they were found.

The red clay lies on the flanks of the hills to the south of the marsh, and is readily detected in the fields at a considerable elevation above the gas-works. We find it also in the fissures and caverns of the Great Orme, where it has been

protected from denudation; and a clay of a similar character occurs on the shore of Colwyn Bay, where it includes, in places, lenticular patches of sand.

This clay, so widely spread over the district, seems to point to different conditions during its accumulation, to those obtaining during the aggregation of the till; while the latter may be considered the *moraine profonde* of the old glaciers, the red clay suggests marine transport during a period of submergence of the land. Instead of a local origin, a distant source must be assigned to it, as it can be traced eastwards and northwards in now disconnected deposits, but which were probably once continuous, at least over the lower lands.

Before concluding, I should like to mention another incident in the recent geological history of Llandudno,—that of the formation of a raised beach or bank, composed of shells, shelly sand, and gravel, which appears to extend from the shore, underneath the Promenade, right across Mostyn Street, to a distance of at least two to three hundred yards from the bay.

Last autumn, during the excavation for the foundation of a building in the central portion of Mostyn Street, I had an opportunity of examining the deposit, which certainly either overlies or entirely replaces the clay which covers the marsh.

In this excavation nothing was disclosed but beds of shells, mixed with shelly sand and very small gravel, to a depth of about six feet, with about one foot of surface soil. Most of the shells are much rolled and worn, and have probably been drifted here by the tidal currents then prevailing. They are all, I believe, of species now inhabiting the adjoining seas. The most abundant shells were the *Pectens* and the *Mytilus Edulis* or common mussel.

List of Shells found at Llandudno, September 13th, 1880.

(Nomenclature as used in "British Conchology" of Dr. Gwyn Jeffreys.)

Anomia ephippium.
Ostrea edulis (fragments.)
Pecten varius (plentiful.)
„ opercularis, junior (plentiful.)
Mytilus edulis (plentiful.)
Nucula nucleus.
Cardium edule (plentiful.)
Tapes pullastra.
„ decussatus.
Tellina balthica.
Mactra solida, junior.
„ subtruncata (more plentiful than "solida.")
Scrobicularia alba.
Corbula.
Mya (fragments.)
Patella vulgata (plentiful.)
Trochus cinerarius.
„ umbilicatus.
„ (tumidus ?)
„ zizyphinus (fragments.)
Littorina obtusata (plentiful.)
„ rudis.
„ litorea.
Rissoa costulata.
Hydrobia ulvæ.
Buccinum undatum (fragments.)
Murex erinaceus (fragments.)
Fusus antiquus (fragments.)
Nassa reticulata.

The discussion was deferred to a future meeting.

Note by Mr. A. W. Waters on a Memoire by M. E. Vanden Broeck, on the Phenomena of alteration of superficial deposits by means of the infiltration of atmospheric water.

In the library of this Society there are several papers by M. Ernest Vanden Broeck on the alteration of superficial deposits by means of infiltration of surface water, but in the present large and valuable communication* entrusted to me to hand to you, the subject is reviewed, and the observations are extended, and their importance shown in fresh fields of enquiry.

The rain falling upon the surface of the soil contains a considerable quantity of carbonic acid and oxygen, and the quantity of carbonic acid is often increased during the infiltration of the surface, or organic soil. This slightly acid water acts slowly upon all rocks, but with most rapidity on calcareous rocks when the lime or other matter is dissolved out, leaving, in the of case calcareous grits, &c., or fossiliferous sands, merely siliceous sands or clay, formed in consequence of the removal of the lime; but the action of the water is by no means confined to the calcareous rocks, for feldspathic are, as all know, much affected by water, especially if it contains carbonic acid, and still more actively if there is sulphate of ammonia, or chloride of sodium; granites are rapidly changed into kaolin; and when speaking of this, instances are given showing the time taken for feldspathic rocks to be decomposed, which sometimes occurs even to a considerable depth, one porphyr

* Mémoire sur les phénomènes d'alteration des depôts superficieles par l'infiltration des eaux météoriques; par Ernest Vanden Broeck. Mem. Acad. Royales de Sciences de Belgique. Vol. XLIV., 1880.

showing change down to a depth of 45 metres; so also the metalliferous rocks are frequently entirely changed by oxydation caused by the infiltering water, and schistous rocks are in the same way changed into a plastic clay.

Clay itself is not of course changed in this way, but often plays an important part in the series of phenomena in forming an impermeable cover to subjacent rocks and preventing action over a certain area, but changes in the color frequently take place through chemical action thus brought about on the iron contained in it, and this may be seen where roots enter into the clay when an ochreous zone is formed round each root and rootlet, and thus the clay may be in the lapse of time changed into a permeable soil by the water entering along the line of the roots.

The clays above calcareous outcrops are frequently formed from similar calcareous rock by the infiltration of the water, as for instance the "terra rossa" in Carniola, is only the residue of the subjacent calcareous formation, and this is also the case with the laterites of India, China, and South America. The siliceous clays at the top of the chalk are considered to be a product of the chalk out of which the calcareous material has been dissolved, and this, at different times and in various places, has been considered of cretaceous, tertiary, or quaternary age. It has been objected to this last proposition that the siliceous clay deposit is too large to have been thus derived, but M. Broeck replies that comparison must not be made with chalk rapidly dissolved in acid in the laboratory, for when the operation takes place slowly, then the ferrous salts are oxydated, and the product of argillaceous and iron residues is under such conditions much more considerable.

In Belgium there was much confusion in the stratigraphical geology until M. Broeck pointed out the

importance of changes thus brought about by water altering the upper and exposed part of a formation. This is perhaps most clearly seen in the eocene, and the sands thus formed, when the fossils were removed, were called "*sables verts sans fossils*," and considered to be another stage, but the same thing is found above the *laekenien*, *wemmelien*, and *bruxellien*, and in each case there was considered to be a fossiliferous and unfossiliferous zone formed at different times, and on account of the irregularity of the division between the unaltered and altered rock, it was even considered that there had been considerable denudation between the formation of fossiliferous and unfossiliferous rock now seen to be of the same age. In some cases where a pocket or hollow is thus formed, the diminution of the mass, through the carbonate of lime being dissolved out of the sand, is clearly shown where there are horizontal bands of grit or bands of substances less easily soluble than the sand, for these bands sink in the middle of the well or pocket, and form a hollow curve, continuous at each side with the horizontal bands in the unchanged area. A section may show several such pockets, with these bands in each case sunk in the centre. Besides these pockets, "natural wells" are formed in the same way, by the infiltering water entering by means of clefts, joints, or depressions. These are really zones of alteration, and in some localities are found to have a definite form, and take a definite direction, and are found in calcareous rocks of various ages.

These changes have taken place in various periods, and instances are quoted in the Devonian; but in the older formations but few of the surfaces of ancient continents are known, but their study may throw much light on geological research and simplify many geological problems. In the tertiaries, however, these zones of alteration are found in

various periods, and sometimes one section even may show that such modification has taken place in the same locality at two widely separated times; for instance, there are several cases where, near the top of the section, a quaternary alteration is demonstrated, and below this there are a series of tertiary deposits, at the base of which in the eocene similar phenomena are seen, which took place when this was land, but previous to the last subsidences when marine deposits were formed overthe already altered eocene.

In the *hesbayen* of Belgium, representing the *loess* of the German plains, there are two layers, the upper of which has been altered by infiltration; and the "*diluvium rouge*" of the Seine basin is only the "*diluvium gris*," &c., changed by infiltration, so that the *diluvium rouge* is not a special deposit, but a mask of altered material covering various deposits.

M. Broeck concludes this most important and suggestive paper,—in which he thoroughly establishes the importance of the phenomena, and shows how frequently it may be observed, but yet how many errors have occurred through its neglect,— by saying it is thoroughly established that the disappearance of fossils, the removal of carbonate of lime, the production of argillaceous residue, the oxydation of ferrous salts and colouring of the deposits yellow, brown, or red, constantly accompanies the alteration of calcareous rocks by means of infiltration of atmospheric water.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART IX. VOL. XVI. SESSION 1880-81.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 28th day of June, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOSEPH DICKINSON, Esq., F.G.S., Vice-President, in the Chair.

The CHAIRMAN said he was sorry to have to announce the death of Sir Philip de Malpas Grey-Egerton, Bart., M.P., one of the oldest Members of this Society, and President on two several occasions.

The following additions to the Library were laid on the table:—

Hull Edward, F.R.S.: Pamphlet on Subsidences of Surface in the Salt Districts of Cheshire in 1881.—*From the Author.* Kinahan G. H., M.R.I.A.: Papers read before Royal Irish Academy. Pamphlets.—*From the Author.* Bulletin of the Museum of Comparative Zoology, Harvard College, Cambridge, U.S.A., No. 5.—*From Professor Agassis.* London Geological Society: Quarterly Journal, No. 146.—*From the Society.* Mineral Statistics of Victoria for 1880.—*From the Royal Society, New South Wales.* Mining Institute of Scotland: Transactions, Vol. III., Part 3.—*From the Council.* Natural History Society, Glasgow: Proceedings; Vol. IV., Part 2.—*From the Society.* North of England Institute of Engineers: Transactions; Vol. XXX., Part 3.—*From the Council.* Annual Reports of the

Inspectors of Mines for 1880; Special Report on the Risca Colliery Explosion, 1880, and Minutes of the Coroner's Inquest; Joint Report by Messrs. Dickinson, Wales, and Cadman, on the Coal-bed or Coal-field in which Risca Colliery is situated; Special Reports on the Pennygraich Colliery Explosion, by Messrs. Wales and Wright.—*From H. Birley, Esq., M.P.* Smithsonian Institution, U.S.A.: Annual Report for 1879.—*From the Institution.* South Wales Institute of Engineers: Proceedings; Vol. XII., No. 5.—*From the Council.* Geological Magazine; No. 205.—*Purchased.*

AUTOMATIC RECORDER FOR VENTILATING FANS AND WATER-GAUGES AT MINES.

In my Annual Report for last year, which has just been made public, there is a paragraph calling attention to the need of an automatic or self-registering apparatus for recording the periodical revolutions of ventilating fans and the height of the water-gauge at mines, the subject having come forcibly under my notice and been represented by me when assisting in the investigation of the Risca explosion last summer, as well as from instances which I afterwards found on going into the matter in my own district. The making of such instruments has, I am happy to say, been taken in hand by Mr. Casartelli, of Manchester; and by Messrs. Bailey & Co., of Salford; and I find by a letter which I have just received, that the latter firm have recently sent such an instrument, called a recorder, to the Towneley Colliery in this district.

The accompanying drawing gives a good idea of what the instrument consists.

It appears that if desired there will be no difficulty in constructing a modification of the instrument to allow of the fluctuations of the atmospheric pressure being also indicated,

W. H. BAILEY'S RECORDER FOR VENTILATING FANS, &c., AT MINES.

PEACE'S ANEMOMETER.

Mr. WALTER EVANS exhibited and explained one of Peace's anemometers, (which, he said, Mr. Dickinson suggested to him might interest some of the members.) It was, he said, invented upwards of 20 years ago by the late Mr. William Peace, of the Haigh Colliery, near Wigan, for registering the velocity of air currents in down-cast shafts. It consisted of an ordinary weigh beam, balanced on knife edges, and carrying a toothed quadrant which worked in a small pinion on the pointer shaft. From one end of the beam a copper cone was suspended, and hung loose in the shaft; upon this the air acted, giving motion to the pointer. The indicator was not made for high velocities, and only registers up to 300 feet per minute.

The CHAIRMAN said that a little time ago it was proposed, he thought, by Mr. Hall, the Inspector of Mines for the Wigan district, that a telephone should be attached to the anemometer, by which means the sound of each tick would be audible in the office, and the manager or person in charge would be able to hear how the air was going in. Mr. Peace's instrument, however, was far simpler because he proposed to have it hung in the shaft by means of a cord and to have a connector brought into the office where it would always be within sight.

Mr. SMETHURST said that the apparatus would do very well as long as they had the same temperature in the shaft and the same dryness, but where they had a changing atmosphere the tin plate would be some days covered with moisture, which would give greater velocity through the greater weight, while on other days it would be very dry.

The CHAIRMAN said Mr. Smethurst's objection would apply only to that part of the apparatus which was hung in

the shaft. The more delicate part was intended to be in the office.

Mr. SMETHURST: Then there would be need of a good length of wire, and the friction from that would be very great. That also would be liable to alteration from changes of the atmosphere.

The CHAIRMAN: Perhaps the arguments you use are potent, but the fact that the instrument has been before the public for a quarter of a century and yet has not come into use is the best answer, that it has not met a public want. Still it is an anemometer, and it is a factor that may guide some one, perhaps, in making a better. The inventor, Mr. Peace, was one of our oldest members, and a very active one.

DISCUSSION ON MR. SMETHURST'S PAPER ON "EXPLOSIVES USED IN MINING,"

Read at the February Meeting of the Society.

In introducing the subject for discussion,

The CHAIRMAN said: *Apropos* of this subject, I may say that a very important opinion has been given by the Attorney-General and the Solicitor-General with regard to the construction of a part of the 8th General Rule of the Coal Mines Act.

A case having recently been submitted for the opinion of the law officers of the Crown as to the interpretation of the requirement in section 51 (8 f 2 (b)) of the "Coal Mines Regulation Act, 1872, making it obligatory on the persons ordinarily employed in the mine to be out of the mine when gunpowder is used, under the circumstances specified in the rule, the Attorney and Solicitor-General have given it as their opinion that the terms "persons ordinarily employed in the mine" in section 51 (8 f 2) (b) would include the

night shift, consisting of labourers engaged in making ready the mine for the mining operations of the miners constituting the day shift, so as to make it obligatory for the persons employed in the night shift to be out of the part of the mine when and where gunpowder is used under the circumstances already referred to. They think the distinction intended to be drawn is between those ordinarily employed in the mine, in whatever capacity, and those specially employed in the blasting operations.

It will make no difference in this district, because we have always taken the view which these two learned gentlemen have now given; but it will make an important difference in several districts where that view has not been held, and where, consequently, a different practice has prevailed. One of the great objects of the water cartridge is to prevent the spread of flame and the ignition of fire damp; and the purpose of that part of the rule upon which the law officers of the Crown have given their opinion was that, in the event of a mistake being made in a fiery mine, and a shot being fired which spread flame by the presence of fire damp, and perhaps also of coal dust, the consequences should be lessened as much as possible by having no one in the mine but those actually engaged in the blasting operations.

Mr. Wild observed that, the object of the water cartridge being to make blasting perfectly safe, its success might bring about some modification of the rule.

Mr. Smethurst said he had always advocated the firing of shots when the colliers were out of the mine. Undoubtedly night was the proper time for it, whether the mine was considered safe or not.

Mr. Burrows: There is one thing with which I quite agree, that the shot lighter's life is quite as valuable as that of any other man, and if shot firing at night can be made absolutely safe, so that nothing shall injure life or property, it ought on that ground alone to be carried out.

Mr. Smethurst: The object of using water is not only to take away the flame, but also to take away the gas which after the firing is given off. The great advantage is that a m ner has not to work in a smoky atmosphere as is the case after shots fired in the ordinary way. I quite expected more opposition to-day, and I hope that there will be further discussion at the meeting which is proposed to be held at Wigan. I would like to mention one thing, that in all our attempts with powder you have not had a single instance in which we could say that the blasting was absolutely safe The hole ordinarily drilled for blasting in coal leaves so little space for water—if you employ powder—that it is not sufficient to destroy the flame and the fumes which are given off. Since the reading of the paper, one or two experiments have been made to see how far we could go. There must be a point where it will become safe, using either dynamite or gunpowder, and we have found that a 2ft. cartridge, with 3 ounces of dynamite, is as far as we can go; if you employ 3½ ounces of dynamite it becomes unsafe. Some further trials have been made with powder in Wales, and in all the cases they have fired the gas using water cartridges 2ft. 6in., with 8 ounces of powder.

The Chairman: Can you say from your experiments, whether with dynamite and ten water cartridge, gas would be lighted?

Mr. Smethurst: I can say, having gone very carefully into the question, that such a cartridge as I have mentioned charged with 3 ounces of dynamite can be fired with safety, that, however, is as far as you can go; beyond that it becomes unsafe.

Mr. Tonge said that he had made a considerable number of experiments, but with powder only, and he had found as Mr. Smethurst said, that the larger the proportion of water used to the powder, the better was the result. A large

number of shots were fired without any flame. Sparks were seen, but these, we felt convinced, were from the fuse employed.

Mr. SMETHURST: Several times, when using powder in the pit, with the water cartridges, we thought we did not see flame—only a sort of incandescent matter coming from the hole; but the question was, would it fire the gas? I went into experiments on the surface to try if it would, and I found in almost every case (there were only about two exceptions) that the powder fired the gas. And in every case in water, where they have been trying it, and their system of trying it, has been certainly better than mine, for they had the water cartridge put in the floor and over it a cubical wooden frame, covered with canvas, and filled with an explosive mixture—in every case, or almost every case, upon the cartridge being discharged, the gas was ignited, and not only has the gas been ignited, but they tried a piece of cotton saturated with benzoline, which likewise was set fire to. There is no doubt, however, of the success of dynamite fired by electricity, with a detonation. The water cartridge will add somewhat to the cost.

Mr. PENMAN said that he gathered from Mr. Smethurst that the conclusion he had arrived at was that by using water cartridges combined with dynamite the danger of an explosion was lessened; but that the making of larger holes and the extra tamping would cost more money. Perhaps he had forgotten the fact that "*under increased conditions of safety*" they might have a larger number of men in the mine; if the Act was to be construed according to the law officers of the Crown, and only those actually engaged in the operation of blasting were to be in the mine at the time of blasting, that would be a very serious point.

The CHAIRMAN: That in a fiery mine where the issue of gas is sufficient to show in the lamps. It does not apply to

moderately fiery mines. The enforcement of the rule will undoubtedly lessen the number of lives lost in explosions. In some districts they have been having from 20 to upwards of 100 persons in a mine where blasting operations have been conducted at night, and they have been contending that they were within the law, although many of the men were not there for the purpose of blasting. Anyone resisting the law now will have to fight it. The practice for the future must be uniform.

GEOLOGICAL NOTES, AND SPECIMENS OBTAINED FROM THE MONTON DRAINAGE WORKS, NEAR PATRICROFT.*

By C. E. De Rance, Assoc.Inst.C.E., F.G.S., and J. B. Squire, Assoc.Inst.C.E.

Mr. De Rance said: The communication I am about to bring before you is necessarily, to a great extent, matter of detail; I therefore, only wish to read such of the facts and figures as may be found necessary. The drainage-works, which are the subject of this communication, are at Monton Green, near Patricroft. Mr. Squire, the contractor, and joint author of this paper (who is present), determined to accurately note and sketch the various phenomena met with, and to collect and label every specimen as he found it. The result of this has been the two sections now exhibited. The upper section represents the Rocky Lane Tunnel, with eleven shafts sunk from the surface and a length of open cutting at the N.E. end, nearly the whole of that

*The Maps and Sections, in illustration of this Paper, are deposited in the Society's Library, for reference.

section being in the New Red Sandstone. The other section, the SLACK LANE TUNNEL, is in a more easterly direction, with eleven shafts also, and an intermediate length of open cutting, and is entirely in the Upper Coal Measures—the measures lying about the Worsley 4ft. coal. Mr. Squire collected specimens which filled three boxes, which he kindly sent to the Jermyn Street Museum, giving the officials there, the first choice of the fossils and rock specimens. Some chosen were of considerable interest; but, at the same time, I have taken good care that you have on the table a representative collection of the specimens which he met with.

The important system of north-north-westerly faults which range across the Lancashire coal-fields, are too well known, from the labours of Messrs. Binney, Dickinson, and Hull, to require any general description; their important economic influence in separating the district into definite coal-belts, and their influence on the flow of underground water in the coal measures is well understood.

The district which is the subject of the following notes, is situated between two faults of this system, both with easterly downthrows, and at the edge of the coal-field at Monton, near Patricroft.

The eastern, or *Irwell Valley Fault*, can be traced for 25 miles, from the banks of the Ribble, between Samelsbury and Balderstone, to the Irwell at Hulme; it crosses the trough of Lower Coal Measures at Fenniscowles, west of Blackburn, and throws up the extensive tract of Kindescout Grit, forming the hills of Anglezark Moor and Rivington, lying west of the upper reservoirs of the Liverpool and Bolton water supplies. East of Halliwell it throws the Gannister Series on the west against the Bolton 4 feet and 10 feet coal seams; following the valley of the Croal to Farnworth, it throws the Arley-mine measures against the Worsley 4 feet mine measures, the throw of the fault being

here equal to the whole thickness of the Middle Coal Measures.

From Kearsley to Pendleton, by Clifton and Pendlebury, the easterly downthrow, has been the means of preserving from demolition the triangular tract of New Red Sandstone lying between Salford, Ringley, and Cheetham Hill, the base of the red rocks being thrown back 5 miles to the north, by the horizontal displacement of the fault.

The western, or *Worsley Fault*, can be traced in the Worsley 4 feet mine measures to Monton, where it throws in the upper part of the Pebble Beds of the New Red Sandstone against Coal Measures, lying probably about 300 yards above the Worsley 4 feet coal, overlaid by Permian Sandstone, underlying parts with limestone bands. The strike of the Permians does not precisely correspond to that of the underlying Coal Measures; different horizons of the latter are overlaid by the Permians.

The Pebble Beds are well seen in the cutting of the Patricroft and Clifton Junction Railway between Slack Lane and Quaker Bridge. The sandstone is current-bedded in long sweeps, and the pebbles of quartz are present, but the sandstone has not the hardness usually present in this subdivision, but the grains of sand are coarse and sub-angular, and differ from what one of us has termed the "millet seed grain," characteristic of the Lower and Upper mottled Sandstones. The latter is seen in the well-known sections at Eccles Station, where the soft bright-red sandstone dips S. 15 E. at 5 degrees. At Monton Green a third fault occurs, henceforth spoken of as the *Monton Fault*. It is represented on the Geological Survey Map as commencing west of Swinton and ranging south, through Hazlehurst Green, by Worsley Workhouse, south of which its course is drawn as doubtful, but is represented as crossing Monton Green, and terminating in the Worsley Fault.

The excavations made by the drainage works prove the *Monton Fault* to fall into the *Worsley Fault* at a point further north than represented on the map.

Both faults have an easterly downthrow, and the fault ranging from Monton, south through Eccles, may be regarded as a combination of the two.

The Rocky Lane section is 2057 feet in length, it was commenced 12th January, 1880, and completed 21st February, 1881; the measures proved, measured in the direction of the full dip, is 1800 feet; it commences at Monton Green, at the junction of Slack Lane and Rocky Lane, and proceeds in a north-east direction to the Folly Brook.

The following details were measured in the tunnels and shafts during the progress of the work. Commencing at Monton Green: *Shaft No. 1.*—116 feet from Junction; surface, 101·77 above Ordnance Datum; and 31 feet deep shows 4 feet of soft loamy clay and 6 feet of marl upper coal measures, of the overlying grey shales, with occasional bands of Sutton limestone, 3 or 4 inches thick. The shales contain *Sphenopteris*, *Pecopteris*, and *Asterophyllites*. Mr. Etheridge, P.G.S., who has kindly examined them, states they are not in a sufficiently good state of preservation for specific determination.

Between the first and second shaft the *Worsley Fault* was crossed at right angles to the heading, and a large quantity of water occurred in it. The fissure of the fault was filled with two materials,—the first, soft red marl, occurring in a trough 6½ feet wide, and containing boulders from the Volcanic Series of the Lake District, the whole evidently derived from the Glacial Drift alone,—the next, a belt, 8 feet wide, of white bleached New Red Sandstone, against the north side; on the face of the fault rest yellow Triassic Sandstones, which are dipping towards the fault. The grain of the white band corresponds to the yellow, and

alteration of colour is due to percolation of water along the face of the fault.

The fault encountered between Shafts No. 1 and 2 acted as a perfectly puddled barrier to the lower or more southern workings, for whilst the headings out of No. 1 Shaft in the coal-measure shale were dry and dusty, great difficulty was experienced in sinking No. 2 Shaft, from the great quantity of water met with; this increased to such an extent that when the headings were driven about two yards in each direction, the shaft was abandoned until the water could be tapped by the up-hill heading from No. 1 Shaft, when the water rose quickly in the abandoned shaft to within 17 feet of the surface of the ground, and maintained that level until the fault was reached. The same difficulty was experienced in all the remaining shafts in Rocky Lane in a smaller degree, until No. 9 Shaft was gained, when it never rose above the roof of the heading, and gradually died out half way along the open cutting. The direction of this fault, from where it crossed the workings, could be distinctly traced across the grass in the adjoining park upon the early dewy mornings.

Among the sandstones, the most compact and difficult to work was the grey sandstone with pebbles of pure quartz, between Nos. 2 and 3 Shaft, and the most easy and loose was the coarse-grained brown, dark red, and green, near to Nos. 2, 8, 9, and 10 Shaft; the sandstone grains increased in coarsness from Monton Green North-eastwards, up to these latter shafts, and then remained about the same, with the exception of the fine grained dark red already named at No. 11 Shaft, and some of the mottled sandstones in and near to the open cutting.

Shaft No. 2.—252 feet from Junction; Surface 104·40, above the Ordnance Datum line, is 33 feet deep, consisting of Boulder Clay of a stiff consistence and brown colour, 4 feet,

resting in 1 foot of yellow sand, forming the capping of the yellow sandstones dipping towards the fault. These reach a thickness of about 34 feet, and contain, to the south of the shaft No. 2, a pocket of grey fuller's-earth. Underlying them are grey sandstones, with occasional pebbles, 20 feet in thickness, traversed by two small faults or string courses, the first hades with the dip is 3 inches in width, with water; the second hades at 80°, and is six inches wide, and gave out a strong spring of water; both faults haded south, and were filled with greenish sand.

Shaft No. 3.—At 396 feet; Surface 110·30 feet above Ordnance Datum; depth 38·10, section, ashes 3 feet; stiff red clay 2 feet; yellow sand 1 foot; red sandstones with marl-partings 11 feet; hard red sandstone 11 feet, resting on yellow sandstone, changing laterally on the dip, into the grey-sandstone already described. The section shows the alteration of colour from red to grey and yellow, to be accidental and local, due to different degrees of oxidation of the included iron.

North of No. 3 shaft, the yellow sandstone reaches 14 feet, and contains in the middle, a bed 18 inches thick, of quartz pebbles, some of large size. Under the yellow-beds is a hard cherty grey-sandstone 18 inches, resting on yellow sandstone, both of which are cut off by an east and west joint, or fault, hading north, throwing up yellow beds, the fissure of this fault, is coated with oxide of iron, in blistered mammillated surfaces. Six feet northwards, occurs another parallel fault, also an upthrow to the north.

The yellow sandstone on the downcast side of this fault, contained quartz pebbles, as did the brown sandstone on the upcast, which was full of water, and about 7 feet thick, resting on red sandstone of the Pebble Beds, which continue to the end of the section. Between the fault just described and Shaft No. 4, four joints with fissures filled with shale

traverse the sandstone, water flowing from the junction of the brown and red beds, north of the most northerly joint.

Shaft No. 4.—Distance 528 feet; surface level 115·73 feet; depth, 42·80 feet; section ashes, 2·0 feet; stiff brown clay, 3½ feet; red shale, 6 inches; red sandstone, 6½ feet; yellow sandstone, 4 inches; red sandstone, 18 inches; red shale and clay, 4 inches; red sandstone with joint leading north, 12½ feet; red ruddle, 4 inches; red sandstone with yellow patches, 8½ feet; brown sandstone, 1 foot. This is the bed met with in the tunnel, and the overlying and the equivalent of the brown and yellow beds occurring there.

Between Shafts 4 and 5 occurs 6 feet of red sandstone, with a band of quartz pebbles in the middle, then 6 feet of red sandstone with a yellow band of 1 foot, with a water-current at the base.

Shaft No. 5.—Distance 662 feet from Monton Green; surface level 120·38 feet; depth, 48·60 feet. After 6 feet of clay covering shows a succession of small layers of red, yellow, and brown sandstone, to a depth of 18 feet when the red sandstone is reached, and at the bottom is the water bearing bed just mentioned, which is overlaid by a triangular mass of brown quartz pebbles.

Between Shafts 5 and 6, under the red beds of No. 6, is a dark brown bed with mica, the top of it is soft, and often yellow, and contains a vein of water. It is cut off by a fault. On the upcast side of this fault are the 41 feet of red sandstone found in No. 6 Shaft; below the bed, with marl partings and pebbles, is a water-run.

Shaft No. 6.—Distance 802 feet; surface level, 123·95 feet; depth, 49·40 feet, consisting of 7 feet of brown boulder clay, the remainder of red sandstone, with occasional pebbles and patches of yellow sandstone.

Northward of No. 6 Shaft, the strata are arranged in an anticlinal arch, the axis of which ranges W.N.W.; they consist of dark red sandstone resting on lighter beds, 13 feet in thickness. The northern dip of the arch is cut off by a small E. and W. fault hading south, throwing up soft red beds about 4 feet; to the north the normal dip is immediately resumed, yellow soft beds, with much water resting on compact red beds.

Shaft No. 7.—Distance 985 feet; surface level, 126·50 feet; depth, 50·93 feet; soft brown and grey clay, 2½ feet; stiff brown clay, 1 foot; blue clay with boulders, 2 feet; stiff brown clay, 6 inches. The surface of the rock is very hard, and the dip forms an angle with it; in the planes of current bedding are beds of quartz-pebbles. The sandstone at the bottom is much broken, and intersected with joints and beds of yellow sandstone; the joints in the red sandstone are filled with clay, those in the brown sandstone underlying it are filled with brown sand and water. A joint of four-inches, filled with blackish brown material and water, limits the brown sandstone to the south, and introduces red to the north.

Shaft No. 8.—Distance, 1,112 feet; surface level, 125·80 feet; depth, 49·55 feet. Section 7 feet of brown Boulder Clay, and the remainder of red sandstone, with an intersecting bed of yellow sandstone fifteen inches thick, half way down, covered with red ruddle in large flakes, nine inches thick, which to the north is disposed in a synclinal curve, in which lies a laticular mass of coarse grained dark green sandstone, and under it red and soft yellow sandstone; the latter contains springs of water.

Northwards, the normal dip resumes, and lenticular masses, come in the direction of the dip, of quartz-shingle, and of sandstones with green spots.

Shaft No. 9.—Distance 1252 feet, surface level 125·90 feet, depth 44·90. Section brown clay 5 feet, resting on red sandstone, with patches of yellow, resting on pale green sandstone with yellow spots, 2 feet thick. Under is 10 feet of dark-red, coarse-grained sandstone, with nodules of brown ironstone and ruddle, of large size, resting on yellow or brown beds. The colour of the latter, is cut off by a joint hading north.

Shaft No. 10.—Distance 1396 feet; surface level 121·50 feet; depth 39·70 feet. The surface of this rock is worn into a gulley or channel, filled with red and yellow marl, and *debris* of sandstone. Beneath are red-beds with yellow patches; under them occur 8 feet of coarse grained brown sandstone, resting on very compact, dark brown, micaceous sandstone, 5 feet. Then occur red sandstones, alternating with pale green beds, traversed by yellowish thread-like markings; red sandstone, with brown and black-coated quartz pebbles, sandstone intersected by joints, and containing patches of red marl of various shapes, overlying a bed deeply stained with pencil-shaped iron markings.

Shaft No. 11.—Distance, 1612 feet; surface level, 112·68 feet; depth, 29·68 feet. The drift has thinned out. Dark red sandstone, with seams of yellow, and deep purple pencil markings, 3 feet; yellow sandstone, 1 foot; coarse red sandstone 16½ feet, with a seam of water, hading with the dip; bright yellow sandstone, 1 foot; fine ground red sandstone, 10 feet; to the north, strata are apparently broken, by an upcast fault, bringing up very dark red sandstone.

These beds may be correlated with the Lower Mottled Sandstone; they resemble beds of that age discovered in the Bootle well boring near Liverpool, beds in a railway cutting near Prescot, and beds resting on the Coal Measures in the

Winwick boring north of Warrington, already described by one of us.*

Open Cutting.—In the open section, coarse-grained sandstone, alternating with shales and beds of quartz pebbles, overlie exceedingly current-bedded and jointed sandstone, the joints being filled with clay, extending from 1759 feet to 2022 feet, where the sandstone surface runs out of the section, dipping quickly towards the Folly Brook; the surface level descends from 107·10 feet above the Ordnance Datum to 99·00 feet. The rock-surface is overlaid by marsh ground to a depth of 5 feet at the southern end, while further north, 2 feet of old soil and decayed vegetation intervenes. At the level of 100 feet, on the southern side of Folly Brook, the surface of the rock descends beneath this level, and between it, and the old vegetable-soil, occurs in descending order,—soft blue clay 2 feet, grey loamy sand thinning out southwards 2 feet; coarse green sand with large boulders of granite, greenstone, and other erratics from the Lake District, clay and glacial detritus, blocks of sandstone, thickening towards the valley, 4 feet.

Slack Lane Tunnel, commenced 14th January, 1880, completed 25th August, 1880, between the Monton Green Junction and Eccles Road, east of Western Goods Railway to Clifton Junction, is a distance of 1,523 feet, in a south-east direction; the measures observed in the cuttings dipped to this point of the compass at 7°, but the true dip is more southerly at a higher angle. From the Monton Green Junction to the No. 1 Shaft are stiff grey shales without water.

Shaft No. 1.—Distance, 106 feet. Surface level, 99·97

* Further notes on Triassic Borings, near Warrington, Trans. Man. Geol. Soc., 1880.

feet above Ordnance Datum; depth, 29 feet 6 inches. Section—loamy clay, 3 feet; stiff brown clay, 18 inches; thin blue shale, 8 inches; coal-bass, 6 inches; grey fireclay, 17 inches; calcareous conglomerate, 2 feet in the shaft, thickening south-eastwards.

Shaft No. 2.—Distance from Monton Green Junction, 270 feet; surface level, 99·31. Section—loamy clay, 3 feet; stiff brown clay, 18 inches; grey shale with coal measure ferns (in which *Neuropteris* is plentiful), 22 feet; and a thin coal seam, 8 inches, met with in the after shaft of No. 1.

Shaft No. 3.—Distance from junction, 412 feet; surface level, 99·28 feet above O.D.; depth, 27·17 feet; stiff brown clay, 6 feet; yellow marl, 15 feet 9 inches. Hard cream-coloured sandstone passing downwards into grey flags.

Shaft No. 4.—Distance from junction, 561 feet; surface, 100·37 feet; depth, 27·50 feet. Section—stiff brown clay, 12 feet (boulder clay); soft grey fireclay, 18 inches; stiff grey shale.

Shaft No. 5.—Distance from junction, 716 feet; surface leval, 101·24 feet; depth, 27·57 feet. Section—stiff brown clay (boulder clay), 12 feet; yellow marl, 4 feet; fireclay, 3 feet 6 inches; coal, 6 inches; soft grey fireclay, containing *calamites*.

Shaft No. 6.—Distance from junction, 859 feet; surface, 101·89 feet; depth, 27·49 feet. Section—stiff brown clay (boulder clay), 9 feet; black marl (worked-up fireclay), 8 feet; grey shale (with sandstone partings 3 inches thick), 2 feet; bluish shale, 2 feet; "Sutton limestone," 2 feet.

Shaft No. 7.—Distance, 1,020 feet; surface level, 101·05 feet; depth, 25·83 feet. Section *a*, brown clay, 7 feet (Boulder Clay); *b*, bed probably re-arranged, red marl, 3 ft. 6 in.; red shale, 3 ft. 6 in.; red mottled grit stone *(c)*, 1 ft. 6in.;

in all, 8 feet 6 inches; *d*, Sutton limestone, 1 foot; grey flaggy sandstone, 16 inches, and stiff grey shale, on which the sandstone rests on an apparently eroded surface. Liassic ammonites occurred in the drift, resting on the actual face of the rock, derived probably from Yorkshire.

Shaft No. 8.—Distance from junction, 1,145 feet; surface level, 98·22 feet; depth, 23·24 feet. Section—Re-arranged beds, mixture of sandstone, and ironstone nodules, 8 feet; soft red sandstone, 6 feet. (Coal measures) and pink coloured shale, in horizontal layers, resting against an upward wedge of purple marl, which filled the headings.

Shaft No. 9.—Distance, 1,277 feet; surface level, 95·16 feet; depth, 18·50 feet. Section—soft brown (boulder) clay, 14 inches; purple marl, 2 feet; red and yellow marl, 2 feet; black, finely laminated shale, 3 inches; yellow marl, 6 inches; black, lumpy shale, 2 inches; soft brown ironstone, 6 inches; black, marly clay, 2 inches; grey and red marl, 3 feet 6 inches; hard, lumpy ironstone, 6 inches, with yellow, serrated under-crust; yellow marl, 6 inches; limestone, locally called "Sutton Limestone," 1 foot 6 inches, overlying—in the heading to the westward—3 feet of dark brown shale, containing small hollow boulders.

Shaft No. 10.—Distance, 1,323 feet; surface level, 94·30 feet; depth, 18·40 feet. Section—soft brown (boulder) clay, 2 feet 4 inches; purple marl, 10 feet 6 inches, overlying shale, with small flat boulders.

Open Cutting.—Commenced at 1410 and continued to 1470 feet, the surface levels being 95·10 and 95·80 feet respectively above Ordnance Datum, and the depth averaging 18 feet; the section shews a bed of yellow sand, close to the surface at the west end, about 3 feet thick, running down to 2 feet thick at the east end, where it is covered with alternate layers of red and brown clay, about 4 feet deep, running out in a surface wedge half-way along

the cutting; beneath this bed of yellow sand, for a parallel depth of 2 or 3 feet, are a number of thin layers of various coloured sands, marls, and sandstones, terminating in a thick bed of very hard green and red mottled gritstone.

Shaft No. 11.—Distance, 1,523 feet; surface level, 96·28 feet; depth, 18·28 feet. Section — Coarse sand, 12 inches; soft, brown clay, 3 feet 3 inches; red clay, 21 inches; red marl, yellow clay, and white sandstones, in alternate layers, 5 feet 3 inches; and the rock described in the open cutting—except that here the red colour predominates—and a good deal of water occurs in the beds and joints.

Between shafts 4 and 5, two seams of coal, each 8 inches thick and 3 inches apart, traversed the heading for a length of 20 yards, dipping S.S.W. about 10°.

Between shafts 6 and 7 there is a bed of compact fire-clay, five feet thick, passed through, which rebounded to the workmen's tools almost like india-rubber; in the shales overlying this bed, *Stigmaræ* and other fossils were found.

In the eastward heading from No. 10 shaft, and approaching near to the open cutting, a number of large glaciated boulders were found, in a sort of channel course, embedded in the purple shale, and actually lying underneath the rock, dipping south at about 15°.

The Chairman, referring to the statement in the paper that the line of the fault had been traced by the colliers by the rankness of the grass, said that that was nothing new in the colliery districts.

Mr. De Rance: No, we find it so on the Geological Survey—rushy ground indicating springs often gives the clue to a line of fault.

The CHAIRMAN said that, independently of the water which might be kept back by faults—and no doubt it often was so—it had been observed by many old people in Lancashire and elsewhere that over the lines of great faults there was frequently a slight difference in the temperature; and by the dew point early on a summer's morning many of the principal faults in Lancashire have been traced out before they were discovered underneath the drift.

Mr. DE RANCE said it would be an interesting thing if some one would take the dew point and temperature of the ground over faults, to ascertain through what vertical amount of supervening drift, the effect of difference of temperature in underground faults could make itself felt. If some members of this Society were each to take up a district it might very soon be done.

Mr. SQUIRE gave some details in regard to the sections exhibited, and to the position in which some of the specimens were found.*

The CHAIRMAN said it was desirable that engineers and contractors should make notes of sections. A quarter of a century ago in the Institute of Civil Engineers it was suggested that they should make it one of the grounds of entry into the Society that young engineers had noted the sections of railway cuttings.

Mr. DERANCE said at the museum in Jermyn-street several hundred sections were preserved in pigeon-holes. They were plotted between the years 1840 and 1850; they chiefly represented railway cuttings through the West of England and Midland Counties. They were made, he believed, in connection with the Board of Trade. They were handed to Sir Henry de la Beche, the Director at that

* The collection exhibited has since been accepted by Professor Boyd Dawkins, F.R.S., for the Owens College Geological Museum.—C. E. R.

time of the Geological Survey, for the use of his staff: since then they had been entombed in a large press, and there they were covered with dust, and but few people knew of their existence. He (Mr. DeRance) wanted to know something about a railway cutting near Connah's Quay, and found a most carefully prepared and coloured section, drawn to scale, in that press. The exact circumstances under which these sections were made he did not know, but they were of official origin. He imagined that the Board of Trade ordered the work to be done, that it was carried to a certain point, and then abandoned.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART X. VOL. XVI. SESSION 1881-82.

ANNUAL MEETING.

The ANNUAL MEETING of the Members of the Society was held on Tuesday, the 25th day of October, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOSEPH DICKINSON, Esq., F.G.S., Vice-President, in the Chair.

Mr. Arthur S. Pennington, Solicitor, Wood Street, Bolton; Mr. J. B. Squire, A.Inst.C.E., Worston House, Durning Road, Liverpool; Mr. Wm. Wandless, Colliery Manager, (Westhoughton Coal and Cannel Co., Limited), Westhoughton, near Bolton, were elected ordinary members of the Society.

The Hon. Secretary announced that the following Books have been received since the last Meeting.

Accidents in Coal Mines: First Report from the Select Committee on, with Minutes of Evidence, &c., 1854.—*From John Thomas Boot, Esq.* Canadian Institute, Toronto: Proceedings, Part II., Vol. I. New Series.—*From the Institute.* Chester Society of Natural Science: Annual Report, 1880-81.—*From the Society.* Edinburgh Geological Society: Transactions, Part I., Vol. IV.—*From the Society.* Edinburgh Royal Physical Society:

Proceedings, Session 1879-80.—*From the Society.* Epping Forrest and County of Essex Naturalists' Field Club: Transactions, Part IV. (1st Part, Vol. II.)—*From the Club.* Fossil Sponge Spisules from the Upper Chalk, by G. J. Hinde, F.G.S.—*From the Author.* Geological Magazine: Nos. 206-209.—*Purchased.* Institution of Mechanical Engineers: Proceedings. No. 2, 1881.—*From the Institute.* Iron and Steel Institute: Jurnal. No. 1, 1881.—*From the Institute.* Leeds Philosophical and Literary Society: Annual Report, 1880-81—*From the Society.* Leicester Literary and Philosophical Society: Transactions, Part 7; Sessions, June, 1860-65; Report, 1880-81,—*From the Society.* Liverpool Geological Society: Proceeding, Parts 3, Vol. IV.—*From the Society.* London Geological Society: Quarterly Journal, No. 147—*From the Society.* London Geologists' Association: Proceedings, No 2, Vol. VII.—*From the Association.* Midland Institute of Mining Engineers: Transactions, Part IV., Vol. VII.—*From the Institute.* Mining Institute of Scotland: Transactions, Parts IV.-VI., Vol. III.—*From the Institute.* North of England Institute of Mining and Mechanical Engineers: Transactions, Part IV., Vol. XXX.—*From the Institute.* Royal Society, London: Proceedings, Parts 192-95, Vol. 28; Vols. 29-31; and Parts 212-15, Vol. 32—*From the Society.* Royal Society of New South Wales, Sidney: Journal and Proceedings, Vol. XIV., 1880—*From the Society.* South Wales Institute of Engineers: Proceedings, No. 6, Vol. XII.—*From the Council.* Warwickshire Naturalists' and Archaeologists' Field Club: Proceedings, 1880—*From the Club. Pamphlets*: Various Papers by M. A. Rutot. *From the Author. Pamphlets:* Split and other Boulders (Paper read before Liverpool Society), by Charles Ricketts, M.D., F.G.S. Report (Quarterly) of the Mining Surveyors and Registrars, Victoria, January to March, 1881—*From the Royal Society, New South Wales.* La Société Vaudoise des Sciences Naturelles: Bulletin, 2e S., Vol. XVII., No. 85—*From the Society.* Deutshen Geologischen Gesellschaft: Zeitschrift, Heft II., Band XXXIII.—*From the Society.* Halle a/s, Vereins für Erdkunde: Mittheilungen, 1881—*From the Society.* Rio de Janeiro, Musen Nacional: Archivos, Vols. II. and III.—*From the Council.* St. Petersburg, L'Académie Impérial des Sciences: Mémoirs, VIIe Serie, No. 1-7, Tome XXVIII.; Bulletin Feuilles, 1-17, Tome XVII.—*From the Academie.* Rapport de Mission, Par. MM. A. Pernolet et L'Aguillon, a la Commission Chargée de l'Etude des Moyens propres a prevenir les Explosions de Grisou dans les Houillères en Belgique, en Angleterre, et en Allemagne, 1881. *Purchased.*

The Report of the Council and the Treasurer's Balance Sheet were read by Mr. J. S. Martin, Hon. Secretary.

REPORT OF THE COUNCIL FOR 1880-81.

During the Session just concluded, the Society has satisfactorily maintained its position in all respects. The papers which have been brought forward were of interest and value, and were discussed in many cases at considerable length, and with evident interest. The meetings have been well attended, and a lively appreciation has been generally shown as to the work of the Society. The number of members has increased. The assistance of the members is requested both as to the introduction of suitable persons for election, and with a view of providing papers to be read and discussed.

The number of members on the register at present is as follows, viz. :—18 honorary, 8 life, and 166 ordinary, as compared with 18 honorary, 10 life, and 160 ordinary, last year.

The following have been the changes :—

	Resignation.	Death.	Defaulter.	Total.	New Members.
Life	..	2	..	2	..
Ordinary	3	1	1	5	11

The income of the Society has, with due regard to ecomomy, been sufficient to pay current expenses; and the balance in the Treasurer's hands has been increased from £19 15s. 11d., to £71 7s. 5d. The outstanding liabilities are, as usual at this period, small.

The Council deem it desirable to remind members that considerable work is thrown upon the Hon. Secretaries by the delays in payment of subscriptions. In accordance with the Rules of the Society all subscriptions are due in advance

on the first of October in each year. It is with regret that the Council has found it necessary to strike off one name from the list of members, in consequence of neglect to pay subscriptions.

Two meetings during the Session were held at Wigan; one was only formally held in consequence of a request from the local authorities, who deemed it undesirable that a full meeting should be held, owing to the disturbed state of the district through an extensive strike of colliers at that time. The experiment has been so far successful that it is proposed to again meet there during the ensuing Session.

Your President having kindly invited a party of the members to visit him at his shooting box, at Barton, in Westmoreland, a party of the members, numbering 19, availed themselves of the invitation, and spent a most agreeable day. Their host had made such admirable arrangements for their reception, that they were enabled to get over a considerable part of the country after being entertained at luncheon. Unfortunately his programme was somewhat interfered with by the weather, which prevented the neighbourhood of Auderley Hall being seen to advantage; but the party were most courteously and hospitably received at the Hall by the Countess of Bective, and were enabled to admire the fine specimens of plants, etc., contained in the beautifully arranged conservatory.

The Library has continued to receive many valuable additions through exchange with other Societies, presentations and purchase. The list of which will be found appended.

It is with feelings of sorrow that the Council refers to the loss which the Society has sustained through the death of one of its oldest members, Sir Philip de Malpas Grey-Egerton, who for many years took an active interest in the work of the Society; and of Mr. Eli Walsh also many years a member.

THE FOLLOWING IS A LIST OF PAPERS AND COMMUNICATIONS WHICH HAVE BEEN BROUGHT BEFORE THE ORDINARY MEETINGS DURING THE SESSION.

1880.

November. Dickinson, Joseph, F.G.S., "Discovery of Rock Salt at Preesal, Lancashire."

Woodward, H. A., C. & M.E., "On Temperature of Strata, &c."

Wild, George, "On Marine Fossil Shells at Ashton Moss Colliery Sinkings, near Ashton-under-Lyne."

Watts, William, F.G.S., "On Artic Peat Bog," near Oldham.

December. Tonge, James, F.G.S., "On Blasting in Mines with Water in the Bore-holes."

Macnab, James, "On Blasting with Water."

1881.

January. Kinahan, G. H., M.R.I.A., "On Iron Masked Rocks."

Boot, John Thomas, C. & M.E., "Sections of Collieries, in the Midland Coal Field."

February. Discussion of W. J. Grimshaw, F.G.S., and Herbert Phillips' Paper, "On the Long Wall System of Working Coal."

Smethurst, William, F.G.S., "Explosives used in Mining."

March. Embleton's Ring for Testing Safety Lamps.

Discussion "On Marine Fossils at Ashton Moss" (see November).

Hall, Henry, "A Reply to recent Articles on Colliery Explosions which have appeared in the pages of the *Nineteenth Century*."

April. Discussion continued on W. J. Grimshaw, F.G.S., and Herbert Phillips' Paper, "On the Long Wall System of Working Coal."

Black, W. J., F.R.C.S.E., F.G.S.Ed., "On Extinct Volcanoes of Auvergne, France."

May. Stirrup, Mark, F.G.S., "On the Glacial Geology of the district of Llandudno, with especial reference to the Boulder Clays."

June. Dickinson, Joseph, F.G.S., "On Automatic Recorder for Ventilating Fans and Water Gauges at Mines."

Evans, Walter, "Description of Peace's Anemometer."

De Rance, C.E., F.G.S., Assoc.Inst.C.E., and J. B. Squire, Assoc.Inst.C.E., "On Geological Notes and Specimens obtained from the Monton Drainage Works, near Patricroft.

Discussion.

Dr. MANCHESTER GEOLOGICAL SOCIETY.—BALANCE SHEET. *Cr.*

Abstract of Receipts.

	£	s.	d.
1880-81.—To Balance brought down	19	15	11
,, Birkenhead Dividends	23	8	6
,, Sale of Transactions	6	6	6
,, Subscriptions and Arrears..	172	0	0
	£221	10	11
1881.			
To Balance brought down, due to Society .	71	7	5

Abstract of Payments.

	£	s.	d.
1880-81.—By Library	9	17	0
,, Transactions.....	54	10	1
,, Reporters.....	11	16	0
,, Circulars, Stationery, &c. ..	11	16	0
,, Postages	20	3	7
,, Collector's Commission	8	18	4
,, Rent, &c.....	30	0	0
,, Attendance	2	10	0
,, Insurance.....	0	12	6
,, Balance in the Bank	71	7	5
	£221	10	11

The Investments consist of £600 Four per cent. Guaranteed Stock of the Birkenhead Railway in the names of Henry Mere Ormerod and Andrew Knowles.

Audited and found correct, 25th October, 1881,

HENRY M. ORMEROD, Treasurer.
21st October, 1881.

CLEGG LIVESEY,
EDWARD PILKINGTON, } Auditors.

The Society further possesses a valuable Library, and there are some arrears of Subscriptions.

Alteration of Day of Meeting.

The Hon. Secretary stated that a circular had been sent to the members inviting their opinion upon a suggested alteration in the day of meeting, from the *last* to the *first* Tuesday in each month. About thirty replies had been received, not one of which was averse to the alteration. The only question seemed to be whether the hour of meeting might not be changed to a later hour.

On the motion of Mr. Tonge, seconded by Mr. Woodward, it was unanimously resolved that in future the Society's meetings should be held on the first Tuesday in each month.

Names for Election to be notified on Circulars.

Mr. E. Leader Williams suggested the desirableness of having the names of proposed new members printed upon the circulars convening the monthly meetings, according to the practice in other societies.—The suggestion was approved of by several gentlemen, and was referred to the Council for consideration.

Alteration in Name of Society.

Mr. Tonge suggested the addition of the words "And Mining Institute" to the name of the Society.

The Chairman said that the rules defined the Society's objects to be two, namely, Geology and Mining. No doubt its main strength was amongst its mining members, rather than among the pure geologists. The Society's name was adopted in the first instance as being concise, and he doubted the advisability of altering it now. Under any circumstances, it would require notice to be given.

Mr. Clegg Livesey said he thought it would be a pity to

alter the time-honoured name of the Society, a name with which he had been familiar all his life.

Mr. LEADER WILLIAMS was afraid it might be taken for a sign of weakness—trying to make the Society look younger than it was.

The chair having been vacated by Mr. Dickinson, it was taken by the new PRESIDENT (Mr. Gilroy) who thanked the members for having conferred upon him the honour of the Presidency of that important Society. He was afraid the duties of the office would be inadequately performed, but he promised to do his best, and could only express a hope that the session they had before them would be a successful one. Among the subjects to be discussed there were some which he considered of paramount importance, namely, those dealing with coal mining, and particularly with the use or non-use of explosives. It was well for mining engineers, particularly the younger ones, to turn their attention to that subject, and see if something could not be invented by which the danger at present arising from the use of explosives in mines might be avoided.

On the motion of the PRESIDENT, the thanks of the meeting were voted to the late President (Sir U. Kay-Shuttleworth) and the other retiring officers of the Society, and the business of the meeting was concluded.

In reply to Mr. Stirrup, the Hon. Secretary stated that the large balance in the Treasurer's hands as compared with the balance of the previous year arose from the increased number of subscribing members. The balance from income as against expenditure in the previous Session was about the same as it now is, but an adverse balance had to be cleared off during the two or three previous Sessions, as will be seen by reference to the balance sheets. This prevented the improved state of the Society's finances being so noticeable as at present.

The Report and Balance Sheet were considered satisfactory, unanimously adopted, and ordered to be printed.

The following noblemen and gentlemen were unanimously elected as Officers and Members of the Council for the ensuing year:—

President:

GEORGE GILROY, M.Inst.C.E.

Vice-Presidents:

RIGHT HON. THE EARL OF BRADFORD.
G. S. FEREDAY SMITH, M.A., F.G.S.
WILLIAM BRYHAM.
W. W. B. HULTON.

Ex-Officio Presidents:

JAMES HEYWOOD, F.R.S.
G. W. ORMEROD, F.G.S.
E. W. BINNEY, F.R.S.
JOSEPH DICKINSON, F.G.S.
ANDREW KNOWLES.
G. C. GREENWELL, F.G.S.
JOHN AITKEN.
JOHN KNOWLES, M.Inst.C.E.
THOMAS KNOWLES, M.P.
W. BOYD DAWKINS, F.R.S.
R. CLIFFORD SMITH, F.G.S.
JOHN E. FORBES, F.G.S.
RIGHT HON. THE EARL OF CRAWFORD AND BALCARRES.
SIR UGHTRED J. KAY-SHUTTLEWORTH, BART.

Treasurer:

HENRY MERE ORMEROD, F.G.S.

Secretaries:

JOSEPH S. MARTIN, F.G.S. | JOHN E. FORBES, F.G.S.

Other Members of the Council:

JAMES ATHERTON.
G. C. GREENWELL, JUNR.
W. J. GRIMSHAW, F.G.S.
CHARLES HARDWICK.
JOHN L. HEDLEY.
CLEGG LIVESEY.
MASKELL W. PEACE, F.G.S.
J. F. SEDDON.
W. SMETHURST, F.G.S.
MARK STIRRUP, F.G.S.
GEORGE WILD.
H. A. WOODWARD.

Auditors:

EDWARD PILKINGTON. | JOHN GREENWOOD, JUNR.

NEW ORDINARY MEMBERS.

Aubrey, Richard Charles.

Brown, William Speakman.

Bryham, William, Junr.

Goodall, John.

Grimshaw, H. Stott.

Hodgekiss, John.

Jeffcock, Charles Edward.

Parish, Arthur Woodbyne.

School of Mines, Columbia College. The President (for the time being) of the

Watts, William, F.G.S.

Williams, E. Leader, M.Inst. C.E.

LIFE MEMBERS DECEASED.

Sir Philip de Malpas Grey-Egerton, Bart., M.P.

Eli Walsh.

MEMBER DECEASED.

Jos. Derry.

MEMBERS RESIGNED, &c.

Beswicke, William

Cunliffe, P. G.

Gerrard, Lord of Brynn.

Whipp, Thomas

PAST PRESIDENTS OF THE SOCIETY.

Year of Election.	
1838-9-40	Egerton, The Rt. Hon. Francis, M.P.
1841-2-3	Heywood, James, F.R.S., F.G.S.
1843-4-5	Egerton, Sir Philip de Malpas Grey-, Bart., M.P.
1845-6-7	Mosley, Sir Oswald, Bart.
1847-8-9	Thicknesse, Ralph, M.P., Wigan.
1849-50-1	Heywood, James, M.P., F.R.S.
1851-2-3	Black, James, M.D., F.G.S.
1853-4-5	Ormerod, G. W., M.A., F.G.S.
1855-6-7	Egerton, Sir Philip de Malpas Grey-, Bart., F.G.S.
1857-8-9	Binney, E. W., F.R.S., F.G.S.
1859-60-1	Kay-Shuttleworth, Sir J. P., Bart., M.P.
1161-2-3	Dickinson, Joseph, F.G.S.
1863-4-5	Knowles, Andrew.
1865-5-7	Binney, E. W., F.R.S., F.G.S.
1867-8-9	Greenwell, G. C., F.G.S.
1869-70-1	Aitken, John, F.G.S.
1871-2-3	Knowles, John, M.Inst.C.E.
1873-4	Knowles, Thomas, M.P.
1874-5	Dawkins, Professor W. Boyd, F.R.S., F.G.S.
1875-6	Smith, R. Clifford, F.G.S.
1876-7	Dawkins, Professor W. Boyd, F.R.S., F.G.S.
1877-8	Dickinson, Joseph, F.G.S.
1878-9	Forbes, John E., F.G.S.
1879-80	Lindsay, Lord, F.R.S.
1880-81	Kay-Shuttleworth, Sir Ughtred J., Bart.

LIST OF MEMBERS.

OCTOBER, 1881.

The Names of Honorary Members are printed in *Italics*.
* Members who have compounded for the Annual Subscription.

Year of Election.	
1877	Adamson, Daniel, F.G.S., The Towers, Didsbury.
1874	*Agassiz, Alexander*, Cambridge, Massachusetts, U.S.A.
1863	Aitken, John, Clifton Villas, Urmston. *Past-President.*
1879	Arrandale, John Thomas, Bradford Colliery, Manchester.
1877	Arthur, David, Baxenden Collieries, near Accrington.
1865	Ashworth, Edward, Stagg Hills, Waterfoot, near Manchester
1878	Ashworth, James, Mapperley Colliery, West Hallam, Derby
1878	Ashworth, Thomas, 32, St. Ann's Street, Manchester.
1877	Atherton, James, 16, Acresfield, Bolton. *Member of Council.*
1878	Atkinson, Samuel C., Stand Lane Colliery, Radcliffe.
1878	Atkinson, W. N., H.M. Inspector of Mines, Shincliffe Hall, Durham.
1881	Aubrey, Richard Charles, Standish, near Wigan.
1866	Bamford, J. B., Mining Engineer, Rochdale.
1876	Barnes, R. J., Birley Collieries, near Sheffield.
1875	Barrett, W. S., New Hall, 41, Old Hall Street, Liverpool.
1880	Barton, Richard, jun., Westleigh Lodge, Leigh, near Manchester.
1879	Baxter, Henry, Tyldesley Colliery, Tyldesley.
1858	Bazley, Sir Thomas, Bart., Eyford Park, Stow-on-the-Wold, Gloucestershire.
1877	Beswick, James, Little Hulton, near Bolton.
1838	Binney, E. W., F.R.S., F.G.S., 55, Peter Street, Manchester. *Past-President.*
1867	Bolton, H. H., Newchurch, near Manchester.
1880	Bolton, H. H., junr., Newchurch, near Manchester.
1880	Boot, John Thomas, The Orchards, Hucknall, near Mansfield.

Year of Election.	
1878	Bradford, The Right Hon. the Earl of, Weston Park, near Shifnal. *Vice-President.*
1878	Brocklehurst, Thomas, Dean, Bolton.
1877	*Broeck, Ernest Vanden,* 124, Rue Terre Neuve, Brussells.
1880	Bromley, Thomas, 57, Bank Top, Radcliffe.
1877	*Brongniart, Charles,* Museum d'Histoire Naturelle, 57, Rue Cuvier, Paris.
1861	Brooks, Thomas, Crawshaw Hall, Rawtenstall.
1880	Brown, Wm., Speakman, Pear Tree House, Tyldesley.
1859	Bryham, William, Ince Hall, Wigan. *Vice-President.*
1881	Bryham, Wm., jun., Douglas Bank Colliery, Wigan.
1862	*Buccleuch, His Grace the Duke of, Whitehall Gardens, London, S. W.
1879	Burns, Thomas, Plank Lane Colliery, Westleigh, Leigh, near Manchester.
1875	Burrows, Abraham, Atherton Collieries, near Manchester.
1878	Burrows, John S., Atherton Collieries, near Manchester.
1874	Byrom, W. A., F.G.S., 31, King Street, Wigan.
1879	Carter, James, 1, Granville Terrace, Blackburn.
1878	Clayton, Abel, 11, Chapel Walks, Manchester.
1878	Cooke, Charles, Moston Colliery, Failsworth.
1859	*Coulthart, John Ross, F.R.S.Lit., F.S.A.Scot., Croft House, Ashton-under-Lyne.
1878	Cowburn, Henry, West Leigh, near Manchester.
1879	Crawford and Balcarres, The Right Hon. the Earl of, Haigh Hall, Wigan. *Past-President.*
1880	Crompton, William, Ince near Wigan.
1862	Cross, John, 77, King Street, Manchester.
1860	Crowther, Samuel, Bradford Estate Office, Bolton.
1860	Darbishire, R. D., B.A., F.G.S., 26, George Street, Manchester.
1869	Dawkins, Professor W. Boyd, M.A., F.R.S., The Owens College, Manchester. *Past-President.*

Year of Election.	
1877	*De Rance, C. E.*, F.G.S., Geological Survey, Jermyn Street, London, S.W.
1862	*Derby, The Right Hon. the Earl of, Knowsley.
1856	Dickinson, Joseph, F.G.S., H.M. Inspector of Mines, South Bank, Pendleton. *Past-President.*
1879	Dixon, Charles William, 19, King Street, Wigan.
1879	Drinnan, Richard, Outwood Colliery, near Manchester.
1880	Duncan, Dr., Tyldesley.
1877	Edmondson, Thomas, Cliviger Collieries, near Burnley.
1852	Egerton, The Hon. Algernon, Worsley Hall, near Manchester.
1878	Ellesmere, The Rt. Hon. the Earl of, Worsley.
1838	*Embleton, T. W.*, The Cedars, Methley, Leeds.
1838	*Enniskellen, The Right Hon. the Earl of*, F.R.S., Florence Court, Fermanagh.
1865	Evans, Walter, Longsight, Oldham.
1880	Fairclough, William, Leigh, near Manchester.
1880	Fairley, Joseph Smith, 136, Huskisson Street, Liverpool.
1863	Farrar, James, 12, Market Street, Bury.
1873	Fletcher, Herbert, The Hollins, Bolton.
1875	Fletcher, Ralph, jun., Atherton Collieries, near Manchester.
1868	Fletcher, Thomas, Haulgh, Bolton.
1857	Forbes, John Edward, F.G.S., 46, Hyde Road, Manchester. *Past-President, and Hon. Secretary.*
1873	Garforth, W. E., Colliery Offices, Normanton.
1874	*Geikie, Archibald*, LL.D., F.R.S., Geological Survey Office, Edinburgh.
1856	Gilroy, George, M.Inst.C.E., Hindley Hall, Wigan. *President.*
1881	Goodall, John, Birley Collieries, near Sheffield.
1878	Greener, W. J., Pemberton Colliery, Wigan.
1863	Greenwell, G. C., F.G.S., 8, Prior Terrace, Tynemouth. *Past-President.*

Year of Election.	
1874	Greenwell, G. C., jun., Poynton, near Stockport. *Member of Council.*
1879	Greenwood, John, junr., Ashton Moss Colliery, Audenshaw, Manchester. *Hon. Auditor.*
1879	Gregson, Edward, 11, Chapel Street, Preston.
1880	Grimke, Theodore Drayton, Whitledgehurst, Ashton-in-Makerfield.
1880	Grimshaw, H. Stott, Stand Lane Colliery, Radcliffe.
1864	Grimshaw, W. J., F.G.S., Springfield House, Stand, Whitefield, near Manchester. *Member of Council.*
1877	Grundy, H. T., Radcliffe.
1877	Grundy, Joseph, Radcliffe.
1879	*Guibal, Theophile*, Professeur d'Exploitation des Mines, Mons, Belgium.
1866	Hall, John, Balderstone, Walmersley.
1864	Hall, Robert, Hope Foundry, Bury.
1877	Handsley, Robert, Burnley Colliery Offices, Burnley.
1861	Harbottle, W. H., Orrell Colliery, near Wigan.
1864	Hardwick, C., 72, Talbot Street, Moss Side, Manchester. *Member of Council.*
1880	Hargreaves, John, Winkhill, near Leek, Staffordshire.
1875	*Hawkins, B. W.*, F.G.S., Liverpool.
1874	*Hawkshaw, Sir John*, Knight, F.R.S., 33, Great George Street, Westminster, S.W.
1877	*Hayden, F. V.*, State Geologist, Washington, U.S.A.
1878	Hedley, John L., H.M. Inspector of Mines, Flookersbrook, Chester. *Member of Council.*
1875	Hetherington, Joseph, 22, Booth Street, Manchester.
1874	Hewlett, W. H., Wigan Coal and Iron Co., Wigan.
1880	Heys, James, Westleigh, Leigh, near Manchester.
1838	*Heywood, James, F.R.S., F.G.S., 26, Kensington Palace Gardens, London, W. *Past-President.*
1862	Heywood, Oliver, Claremont, Pendleton.
1876	Higson, John, F.G.S., 18, Booth Street, Manchester.

Year of Election.	
1881	Hodgekiss, John, Downall Green Colliery, Ashton, near Wigan.
1878	Holden, Charles H., Mawdseley Street, Bolton.
1877	Holding, William, Crossall Colliery, near Nottingham.
1878	Hollingworth, George H., F.G.S., Hollinwood, Manchester.
1878	Howell, John, Astley, near Manchester.
1874	*Hull, Professor Edward*, M.A., F.R.S., 5, Raglan Road, Dublin.
1880	Hulton, W. W. B., Hulton Park, near Bolton. *Vice-President.*
1878	Jackson, Charles G., Chamber Colliery Offices, Hollinwood, Manchester.
1875	Jackson, J., 5, Wood Street, Bolton.
1877	Jackson, Lewis, Rocher Colliery, Ashton-under-Lyne.
1880	Jackson, William, Bower Colliery, Hollinwood, Manchester.
1880	Jeffcock, Charles Edward, High Hazels, Sheffield.
1877	Jobling, John, Barcroft Hall, Cliviger, Burnley.
1879	Johnson, Isaiah, Unity Brook Colliery, Kearsley.
1844	*Joule, J. P., LL.D., F.R.S., 12, Wardle Road, Sale.
1880	Kennedy, Matthew, Brinsop Hall Collieries, Wigan.
1879	*Kinahan, G. H.*, M.R.I.A., Ovoca, Ireland.
1856	Knowles, Andrew, High Bank, Pendlebury. *Past-President.*
1859	Knowles, John, Westwood, Pendlebury. *Past-President.*
1877	Knowles, Lees, Westwood, Pendlebury.
1858	Knowles, Thomas, M.P., Darnhall Hall, Winsford, Cheshire. *Past-President.*
1858	Lancaster, John, F.G.S., Bilton Grange, Rugby.
1862	Livesey, Clegg, Woodley, Stockport. *Member of Council.*
1877	Livesey, Thomas, Bradford Colliery, Manchester.
1878	Longbotham, Jonathan, Norley Colliery, Wigan.
1877	Lord, James, Hill House, Rochdale.
1879	Lupton, Arnold, F.G.S., Crossgates, near Leeds.
1861	Lynde, J. G., F.G.S., Gore Street, Greenheys, Manchester.

Year of Election.	
1878	Maiden Samuel, Bridgewater Villas, Stockport.
1873	Martin, Joseph S., F.G.S., H.M. Inspector of Mines, Park Villas, Prestwich. *Hon. Secretary.*
1879	Melling, William, Plank Lane Colliery, Westleigh, Leigh, near Manchester.
1876	Moore, Alfred, C.E., 5, Clarence Street, Manchester.
1833	*Morton Charles*, The Grange, Southport.
1874	*Morton, G. H.*, F.G.S., 122, London Road, Liverpool.
1878	Nall, Simon, Newbold, Rochdale.
1878	Nelson, William, Leigh, near Manchester.
1864	Nuttall, Thomas, Colliery Surveyor, Bury.
1874	*Ormerod, G. W.*, M.A., F.G.S., Woodway, Teignmouth.
1831	Ormerod, H. M., F.G.S., 5, Clarence Street, Manchester. *Hon. Treasurer.*
1874	*Owen, Professor Richard*, D.C.L., F.R.S., &c., South Kensington Natural History Museum, London.
1862	Park, James, Fern Hill, Bury.
1880	Parish, Arthur Woodbyne, Clowes House, Higher Broughton, Manchester.
1880	Parr, Thomas, Westleigh, Leigh, near Manchester.
1876	Peace, George, Monton Grove, Eccles.
1877	Peace, Maskell W., F.G.S., Wigan. *Member of Council.*
1876	Penman, J. Hugh, 2, Clarence Buildings, Booth Street, Manchester.
1877	Pennington, Rooke, F.G.S., 20, Mawdsley Street, Bolton.
1878	Perrin, J. Beswick, M.R.C.S.E., F.L.S., Leigh, near Manchester.
1879	Phillips, Herbert, Digby Collieries, near Nottingham.
1861	Pickup, Peter, F.G.S., Towneley Colliery, Burnley.
1877	Pickup, Peter Wright, Dunkenhalgh Collieries, Church, near Accrington.
1873	Pilkington, Alfred, Clifton Collieries, near Manchester.
1879	Pilkington, Charles, Ashton and Edge Green, Collieries, St. Helens.

Year of Election.	
1873	Pilkington, Edward, Clifton Collieries, near Manchester. *Hon, Auditor.*
1877	Place, W. H., Hoddleston Collieries, Darwen.
1851	Plant, John, F.G.S., Royal Museum, Peel Park, Salford.
1867	Radcliffe, James, Astley Deep Pit, Dukinfield.
1874	*Ramsay, Professor A. C.*, LL.D., F.R.S., &c., 15, Cromwell Crescent, South Kensington, S.W,
1860	Ridyard, John, Walkden, Bolton.
1877	Robins, George, Ashton, near Newton-le-Willows.
1880	*Schofield, Christopher James, Whalley Villa, Whalley Range, Manchester.
1881	School of Mines, Columbia College, New York. The President (for the time being) of the. (To be addressed to Messrs. Asher and Co., Bedford Street, Strand, London).
1873	Seddon, J. F., Great Harwood Collieries, Accrington. *Member of Council.*
1866	Selby, Atherton, Mining Engineer, Leigh.
1878	Settle, Miles, Snow Hill, Darcy Lever, near Bolton.
1877	Shuttleworth, Sir Ughtred J. Kay-, Bart., Gawthorpe Hall, Burnley. *Past-President.*
1879	Sixsmith, John, Syndale Hall Colliery, Chequerbent, Bolton.
1864	Smethurst, William, F.G.S., Garswood Hall Colliery, Ashton, near Wigan. *Member of Council.*
1873	*Smith, R. Clifford, F.G.S., Parkfield, Swinton, near Manchester. *Past-President.*
1838	Smith, G. F., M.A., F.G.S., Grovehurst, Tunbridge Wells. *Vice-President.*
1866	Sopwith, Arthur, F.G.S., Cannock Chase Collieries, Walsall,
1880	Speakman, John, The Walmsleys, Leigh, near Manchester.
1862	Spence, Peter, F.C.S., Erlington House, Seymour Grove, Old Trafford.
1859	Statter, Thomas, Stand Hall, Bury.
1878	Stephens, James Henry, Leigh, near Manchester.

Year of Election.	
1880	Stirrup, Mark, F.G.S., 8, Stanley Terrace, Stamford Street, Old Trafford, Manchester. *Member of Council.*
1880	Teale, William E., Fern Bank, Worsley.
1877	Tomlinson, Thomas, 3, Richmond Terrace, Whitehall, London, S.W.
1873	Tonge, James, F.G.S., Woodbine House, Westhoughton, near Bolton.
1876	Topping, Walter, Ashton, near Wigan.
1858	*Trafford, Sir Humphrey de, Bart., Trafford Park, Manchester.
1876	Unsworth, John, Scot Lane Collieries, near Wigan.
1879	Unsworth. Richard, Mesne Lea Colliery, Worsley.
1877	Waddington, Henry, Burnley Collieries, Burnley.
1877	Waddington, John, Burnley Collieries, Burnley.
1862	Wadham, Edward, Millwood, Dalton-in-Furness.
1879	Walshaw, John, Astley and Tyldesley Collieries, Tyldesley.
1879	Warburton, William, High Lane, near Stockport.
1880	Watts, Wm., F.G.S., Piethorne, Rochdale.
1878	Wells, Samuel B., 130, Bradford Street, Haulgh, Bolton.
1877	West, T. E., 65, Werneth Hall Road, Oldham.
1877	Wheeler, Harold George, Mount Terrace, Manchester Road, Bury, Lancashire.
1880	Williams, E. Leader, M.Inst.C.E., Queen's Chambers, John Dalton Street, Manchester.
1867	Wild, George, Bardsley Colliery, Ashton-under-Lyne. *Member of Council.*
1877	Wild, Joseph, 3, Stoneclough Road, Kearsley, near Bolton.
1876	Winstanley, Robert, 32, St. Ann's Street.
1876	Woodward, H. A., Clifton, near Manchester. *Member of Council.*
1877	Yates, T. M., Anderton Hall Colliery, Blackrod, Chorley.

PRESENTATIONS TO THE LIBRARY, 1880-81.

Birley, Hugh, M.P.—Reports of the Inspectors of Mines, 1880. Special Report on the Penygraig Explosion, by Messrs. Wales and Wright.

" " Risca Explosion, 1880, and minutes of the Coroner's Inquest.

" Joint, on the Coal Field in which Risca Colliery is situated, by Messrs. Dickinson, Wales, and Cadman. *From H. Birley. Esq.*

Belfast.—Natural History and Philosophical Society. Proceedings for Sessions 1878-9, 1879-80. *From the Society.*

Boot, John T.—First Report of Select Committee on Accidents in Mines, 1854.

Cambridge University.—Report of the Museums and Lecture Rooms Syndicate. For 1880.

Cornwall.—Transactions of the Royal Geological Society of. Parts I., II., III. Vol. X. *From the Society.*

Cornwall and Devon.—Reports and Proceedings of the Miners' Association.

Cornwall.—Royal Institution of—Journal. No. 23. 1881. *From the Council.*

Dublin.—Royal Dublin Society:

Transactions.	Vol. I.	Parts	1-12.
"	" II.	"	1-2.
Proceedings.	" I.	"	1-3.
"	" II.	"	1-6.

From the Society.

Dublin.—Royal Geological Society.—Transactions. Part 3. Vol. V. New Series. *From the Society.*

Edinburgh Geological Society.—Transactions. Vol. IV., Part 1. *From the Society.*

Edinburgh Royal Physical Society.—Proceedings Session 1879-80. *From the Society.*

Edinburgh Royal Society.—Proceedings. Vol. X. Nos. 105-7. 1897-80. *From the Society.*

Epping Forest and County of Essex Naturalists' Field Club. Transactions 1, 2, and 3. Vol. I. Part 4 (or Part 1, Vol. II.) Rules, &c. *From the Club.*

Glasgow Natural History Society.—Proceedings. Vol. IV., Part 2. 1879-80. *From the Society.*

Heath, T.—*Pamphlet*—Creswell Caves.

Hinde, G. J., F.G.S.—On Fossil Sponge Spicules from the Upper chalk.

Hull, E., F.G.S.—*Pamphlet*—"Subsidence of Ground in the Salt District of Cheshire in 1881.

Institution of Mechanical Engineers.—Proceedings. Nos. 3 and 4, 1880, and Nos. 1 and 2, 1881. Library Catalogue, 1881. *From the Council.*

Iron and Steel Institute.—Journal. No. 2, 1880, and No. 1, 1881. *From the Council.*

Kinahan, G. H.—*Pamphlet*—Papers read before the Royal Irish Academy.

Leeds Geological Association.—*Pamphlet*—Opening Address of 5th Session.

Leeds.—Yorkshire Geological and Polytechnic Society. Vol. VII. Part 2. New Series. *From the Society.*

Leicester Literary and Philosophical Society. — Transactions. Part 7. 1860 to 1865; and Report for 1880-81. *From the Council.*

Liverpool Geological Society. — Proceedings. Parts 2 and 3. Vol. IV. *From the Society.*

London Geological Society.—Quarterly Journal. Nos. 144-147; Abstracts of Proceedings for the Session 1880-81; *From the Society.*

Catalogue of the Library. *From the Society.*

London Geologists' Association.—Proceedings. Nos. 8 and 9. Vol. VI. 1879-80. Nos. 1 and 2. Vol. VII. 1880-81. *From the Council.*

London.—Royal Institution of Great Britain. Proceedings. No. 72. Part 3. Vol. IX. *From the Council.*

London. — Royal Society. Proceedings. Vols. 28-31, and Parts 212-215, Vol. XXXII. *From the Society.*

Manchester. — Literary and Philosophical Society. Memoirs. Vol. VI. 3rd Series. (Vol. XXVI. old). Transactions. Vols. XVI.-XIX. *From the Society.*

Manchester. — Field Naturalists' and Archæologists' Society. Proceedings and Report for 1880. *From the Society.*

Manchester Scientific Students' Association. — Catalogue of the Library. *From the Council.*

Midland Institute of Engineers. — Transactions. Parts 51-54. Vol. VII. *From the Council.*

Mining Institute of Scotland.—Transactions. Parts 6-11. Vol. II. 1880-81. Parts 1-6. Vol. III. 1880-81. *From the Council.*

North of England Institute of Engineers.—Transactions. Part 5. Vol. XIX. Parts 1-4. Vol. XXX. *From the Council.*

Oxford University.—Catalogue of Books added to the Radcliffe Library in 1880. Per Dr. H. M. Ackland, Librarian.

South Wales Institute of Engineers.—Proceedings. Parts 3-6. Vol. XII. 1881. *From the Institute.*

South Staffordshire and East Worcestershire Institute of Mining Engineers.—Transactions. Vol. IV. New Series. *From the Council.*

The Owens College Calendar. Session 1880-81. *From the Council.*

Ussher, W. A. E., F.G.S.—*Pamphlet.* On Post Tertiary of Cornwall.

Warwickshire Naturalists' and Archæologists' Field Club.—Proceedings. 1880. *From the Club.*

Watford Natural History Society and Hertfordshire Field Club.—Proceedings. Vol. II. Parts - . *From the Council.*

Wigan Free Library.—Catalogue of Works on Mining, Metallurgy, and Manufactures. 1881. *From the Committee.*

ANNUAL REPORTS, FROM THE COMMITTEES.

Chester Society of Natural History. 1880-81.

Chester Society of Natural Science. 1880-81.

Devon and Exeter Free Library. 1880-81.

Dundee Free Library. 1879-80.

Leeds Philosophical and Literary Society. 1879-80, and 1880-81.

Liverpool Free Library. 1879-80.

Salford Museum, Libraries, and Parks. 1879-80.

AMERICA.

Agassiz, Alexander.—Museum of Comparative Zoölogy, Cambridge, U.S.A.

Annual Report of the Curator. 1879-80.

Bulletin. Vol. VI. Nos. 8-11.

Vol. VIII. Nos. 1-4.

Colvin, Hon. Verplanck (Superintendent, N.Y. State Adiróndack Geological Survey).—3rd to 7th Annual Reports on the Progress of the Survey.

Hayden, F. V.—U.S. Geological and Geographical Survey of the Rocky Mountain Region.—Report (with Atlas) on the Geology of the High Plateaus of Utah (J. W. Powell in charge).

U.S. Geological and Geographical Survey of the Territories.

U.S. Geological Survey of the Territories. No. 4, Vol. V.; and No. 1, Vol. VI.

Miscellaneous Publications.—No. 12.—History of North American Pennipeds.

Smithsonian Institution, U.S.A.—Annual Report for 1879. *From the Institute.*

Transactions of the American Institute of Mining Engineers. Vol. VIII. May, 1879, to February, 1880. *From the Council.*

Winchell, N. H.—The Geological and Natural History Survey of Minnesota. Annual Report for 1879.

CANADA.

Selwyn, A. R. C., F.G.S.—Report of Geological Survey of Canada for 1878-79. (With Maps).

Toronto.—The Canadian Institute.—Proceedings, Part II. Vol I. New Series. *From the Council.*

AUSTRALIA.

Mineral Statistics of Victoria for 1880.

Quarterly Reports of the Mining Surveyors and Registrars. Victoria. July, 1880, and to end of March, 1881.

Report of the Chief Inspector of Mines, Victoria, for 1879.

Report.—Of Progress of the Geological Survey of Victoria. Vols. II.-VI. From Thomas Couchman, Secretary for Mines and Water Supply.

Royal Society of New South Wales:

Journal and Proceedings. Vols. XIII., 1879; and XIV., 1880.

Reports (with Atlas for 1879) of the Department of Mines for 1879-80. Sydney.

Report of the Trustees of the Free Library for 1880-81. Sydney. *From the Society.*

FOREIGN.

Académie Impérial de St. Pétersbourg. Mémoires. VIIe Série. Nos. 2-14, Tome XXVII., and Nos. 1-7, Tome XXVIII, Bulletin. No. 5, Tome XXV. Nos. 1-3, Tome XXVI. Nos. 1-7, Tome XVII. *From the Académie.*

Deutsche Geologische Gesellschaft. Zeitschrift. Heften 3 and 4, Band XXXII. Heften 1 and 2, Band XXXIII. *From the Society.*

Naturforschenden Gesellschaft z^c_n Leipzig Sitzungsberichte. Parts 1 and 2. 1880. *From the Council.*

Naturwissenschaftlichen Gesellschaft Isis in Dresden.—Sitzungsberichte. Parts 1-12, 1880. *From the Society.*

Rio de Janeiro.—Musen Nacional Archivos. Vols. II. and III. *From the Council.*

Società Toscana da Scienze Naturali. Pisa Memorie. Vol. IV. Fasc. 2°. *From the Society.*

Société Royale Malacologique de Belgique:

Annales. Tome XII. (IIme Série Tome II.) 1877.

Proces—Verbaux des Seances. January to September, 1880. January to March, 1881. *From the Society.*

Société Vaudois des Sciences Naturelles. Lausanne. Bulletin. Nos. 84 and 85, XVII. 1881. *From the Society.*

Société Géologique du Nord. Lille. Annales. Tome VII. 1879-80. *From the Society.*

Van den Bröck Ernst.—Memoire sur les Phénomenes D'Alteration des Depots Superficiels. *From the Author.*

Verein fûr Erdkunde zu Halle a/s. Mittheilungen. Fûr 1880 and 1881. *From the Society.*

BOOKS PURCHASED 1879-80.

Coal and Coal Mining. Weales Series. By W. W. Smythe. 1880.
Geological Magazine. Nos. 197-209. 1881.
Geological Record. 1877.
Palæontographical Society. *Monograph.* Vol. XXXV.
Reports on the Seaham Colliery Explosion. 1880.
Reports by French Commissioners on the means taken in Belgium, England, and Germany, for the prevention of Explosions in Coal Mines. 1881.

SOCIETIES WITH WHOM THE SOCIETY EXCHANGES ITS TRANSACTIONS, AND INSTITUTIONS AND JOURNALS TO WHOM A COPY IS SENT FREE.

I.—ENGLAND.

London.....British Museum.
Geological Society.
Geological Survey.
Geologists' Association.
Institute of Mechanical Engineers, Victoria Street, S.W.
Iron and Steel Institute.
Royal Institution.
Royal Society.

Manchester ..... Field Naturalists' Society,
Free Library.
Literary and Philosophical Society.
Owens College.
Scientific Students' Association.
Salford Royal Museum and Library.

Barnsley .....Midland Institute of Mining Engineers.
Birmingham.....Free Library and Museum.
Bristol.....Naturalists' Society.
Camborne.....Miners' Association of Cornwall and Devon.
Cambridge .....Geological Museum, University.
University Library.
Chester.....Society of Natural Science.
Chesterfield .....Institute of Mining Engineers, &c. (in bound vols.)

Cornwall .....Royal Geological Society, Penzance.
Royal Institution, Truro.

Dudley .....South Staffordshire and East Worcestershire Institute of Mining Engineers.

Exeter .....Albert Memorial Museum.

Hertford .....Natural History Society and Field Club.

Leeds .....Geological and Polytechnic Society.
Philosophical and Literary Society.

Leicester .....Literary and Philosophical Society.

Liverpool .....Free Library and Museum.
Geological Society.

Newcastle-on-Tyne..Institute of Mining and Mechanical Engineers.

Oxford .....Bodleian Library.
Radcliffe Library.

North Shields ....Public Free Library.

Snaresbrook .....The Epping Forest and County of Essex Naturalists' Field Club.

Stoke-on-Trent....North Staffordshire Institute of Mining and Mechanical Engineers.

Swansea .....South Wales Institute of Mining and Mechanical Engineers.

Warwick .....Natural History Society.

Wigan .....Free Library.
Mining School.

II.—SCOTLAND.

Dundee .....Free Library and Museum.

Edinburgh .....Advocates' Library.
Geological Society.
Royal Society.
Royal Physical Society.

Glasgow .....Geological Society.
Natural History Society.

Hamilton .....Mining Institute of Scotland.

III.—IRELAND.

Dublin .....Royal Dublin Society.
Royal Geological Society of Ireland.
Trinity College Library.

Belfast .....Natural History Society.

IV.—Australia.

Melbourne.....Public Library of Victoria.
Sydney.....Free Public Library.
Royal Society of N. S. Wales.
Newcastle.....John Mackenzie, F.G.S.

V.—Canada and United States.

Montreal.....Geological Survey of Canada (A. R. C. Selwyn, F.G.S., Director).
M'Gill College (Principal, J. W. Dawson, F.G.S.)
Toronto.....Canadian Institute.
Albany, U.S. ....Verplanck Colvin.
Boston, U.S. ....Free Library.
Columbus, U.S. ..Ohio, Geographical Survey of (Dr. J. S. Newberry, F.G.S.)
Easton, U.S. ....American Institute of Mining Engineers.
Indianapolis, U.S. E. T. Cox, State Geologist.
Newhaven, U.S. ..Professor O. C. Marsh, F.G.S.
Washington, U.S. .Smithsonian Institution.

VI.—Foreign Societies.

Berlin.....Geological Society of Germany.
Calcutta.....Geological Survey of India.
Christiania.....Royal University of Norway.
Halle, A.S......Verein fur Erdkunde.
Lausanne (Suisse) Sociétié Vaudoise des Sciences Naturelles.
Lille.....Société Géologique du Nord.
Pisa.....Sociata di Scienci Naturali.
Rio de Janeiro....Museu Nacional.
St. Petersburg....Academy Imperial.
Turin.....Academie Royale.

VII.—Scientific Journals, &c.

Geological Magazine, Geological Record, Mining Journal, Colliery Guardian, Iron and Coal Trades Review.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XI. VOL. XVI. SESSION 1881-82.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 6th day of December, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOHN AITKIN, Esq., Vice-President, in the Chair.

Mr. S. B. Gilroy, Mining Engineer, Cheetham Hill, Manchester; Surgeon-Major W. J. Black, F.R.C.S.E., F.G.S.Ed.; Mr. C. F. Clarke, Mining Engineer, Garswood Collieries, Wigan; Mr. H. Hall, one of H.M.'s Inspectors of Mines, Rainhill; Mr. J. Hilton, Mining Engineer, (Wigan Coal and Iron Company), Wigan; Mr. A. Merfyn, Mining Engineer, 18, Booth-street, Manchester; Mr. A. Pearson, Dukinfield Collieries, Dukinfield; Mr. J. Smith, Mining Engineer, Bickershaw Collieries, Westleigh; Mr. T. Southworth, Hindley Green Collieries, Wigan; Mr. W. MacAlpin, Whinney Hill Colliery, Accrington, were elected ordinary members of the Society.

With reference to the mode of admitting members, to which attention was called at the annual meeting, Mr. J. S. MARTIN (Hon. Sec.) read the following resolution, which had been adopted by the Council, on this subject:—

"That it be an instruction to the Secretaries to announce the names which are proposed for election in the circular giving notice of the meeting at which they may be submitted for election; and that the election shall take place by ballot."

The Hon. Secretaries announced that the following books had been received since the last meeting :—

Cornwall: Journal of the Royal Institution; No. XXIV.—*From the Institute.* London Geological Magazine, No. 210, (purchased). London Geological Society: Quarterly Journal, No. 148, and List of Fellows of the Society for 1881.—*From the Society.* Midland Institute of Mining Engineers: Transactions; Part V., Vol. VII.—*From the Institute.* Mining Institute of Scotland: Transactions; Parts VII.-VIII., Vol. III.—*From the Institute.* North of England Institute of Mining and Mechanical Engineers: Transactions; Part V., Vol. XXX., An Account of the Strata of Northumberland and Durham; Part AB–CE.—*From the Institute.* Kinahan, G. A.; Pamphlets on Irish Geology.—*From the Author.* Reports (Quarterly) of the Mining Surveyors and Registrars, Victoria; April to June, 1881.—*From the Royal Society, New South Wales.* United States Geological Survey: First Annual Report, by Clarence King; Washington, 1880.—*From the Author.* United States Geological and Geographical Survey of the Territories; Vol. VI., No. 2; Washington, September, 1881.—*From the Government.* La Société Vaudoise des Sciences Naturelles: Bulletin, No. 86, Vol. XVII.—*From the Society.* Sitzung's Bericht der Naturwissenschaft-lichen Gsellschaft Isis in Dresden (January to June, 1881).—*From the Society.* Officina Nacional de Estadistica Comercial de la República Argentina, Buenos Aires: (Commercial Statistics,) 1880.—*From the Government.*

DEATHS OF MEMBERS.

The CHAIRMAN said he regretted to have to announce that since the Society had last met they had received notice of the loss of two well-known members by death. One, Mr. W. J. Grimshaw, a member of the Council, had been connected with the Society since the year 1864. He regularly attended the meetings for a considerable period, and at one time held the position of honorary secretary. His interest in geological and mining subjects was shown by the important papers which he contributed from time to time. He was sure they would every one regret his premature decease. The other member whom they had lost was Mr. John Hall, of Walmsley, near Bury.

THE CLAY DEPOSIT AT HEATON MERSEY.

Mr. Mark Stirrup exhibited a peculiarly rounded stone taken from the deposit of clay which is being used at the brick and tile works, Heaton Mersey. The deposit is not a true boulder clay, but is called by Professor Ramsay a "warp" that is a laminated clay laid down by a tidal river.

This clay is very free from stones, and containing a fair amount of sand is easily worked.

The stone now exhibited belonged to the coal-measures sandstones of the locality, its form only struck him as peculiar, considered in connection with the position in which it was found.

In trying to account for that form, he must observe that it had evidently been evenly rolled, its shape did not seem to be such as would be brought about in the bed of a river nor did it appear to be a stone which had been subjected to the action of the waves on a *Shingly* beach, because such stones were flattened—this is rounded.

The conclusion he come to was that it had taken its shape by a process which he had observed in operation on the Holderness coast of Yorkshire, where the cliffs were of boulder clay, and the clay often fell in large quantities upon the beach. The greater part was washed away by the tide, as mud, but occasionally they might see lumps of that clay rolled into exactly the same form—oval or ellipsoid—which this stone from Heaton Mersey presented.

Might not that stone have been subjected to similar action—long continued—upon some ancient sandy beach? And was it possible that its presence in that clay deposit might help them to some further knowledge as to the origin of the clay itself? That was one point of interest. Another was that, on the one part which appeared to have been flattened after it had got that round shape, it presented

marks of scratches, the ordinary glacial striæ, in a longitudinal direction. The flattening might have been caused by the stone getting embedded in shore ice, and thus carried along, and grooved, evidently after it had received its rounded form.

The CHAIRMAN asked if the markings were, in Mr. Stirrup's opinion, really glacial, or might they not be simply marks of laminations in the stone?

Mr. STIRRUP thought there could be no doubt as to their being glacial. The stone would be interesting if it led them to a correct view of the origin of the bed of clay in which it was found. It might tell a tale of there having been an old coast line there.

Mr. STIRRUP also exhibited some nodules, or concretions, of peculiar shape, taken by himself from the boulder clay at Colwyn Bay. He attributed their formation to the action of carbonate of lime upon the clay.

The CHAIRMAN said the formation of the nodules would, no doubt, as Mr. Stirrup had said, be due to the action of carbonate of lime. In places where sand was abundant, of boulder clay origin, found in the neighbourhood of beds of limestone, such concretions were formed in considerable abundance. He had observed a remarkable instance of this in the south of the Isle of Man, where the roof of a cave of considerable size was formed by this means, and numerous instances of the same operation also occurred in the singular concretions found so abundantly in the boulder clay on the Blackpool coast, and which were so generally utilised as ornamental rockery stones at that place.

Professor W. BOYD DAWKINS said that Mr. Stirrup's explanation of the way in which the stone at Heaton Mersey became embedded in the clay was one that he should be inclined to accept. At the present time, after a very severe frost, blocks of stone were carried down

from the region of the upper Dee and dropped among the fine mud which exists at the mouth of the estuary. With regard to the form of the stone, however, he did not feel inclined to accept Mr. Stirrup's views. It seemed to him to be an exceedingly hard and compact sandstone, which had been battered and ground to its present shape by attrition against other hard substances; and he did not think the stone could have been in such a plastic and rollable condition as a lump of clay washed up and down by the waves on the sea shore. With regard to the further point as to whether the stone was worn and battered by the waves of the sea, or by the waters of a river or stream,—that, he thought, was entirely an open question, for he had seen stones of that shape, made of equally hard and compact substances, which had been found in the beds of streams as well as in the shingle of the sea shore.

THE GLACIAL GEOLOGY OF THE DISTRICT OF LLANDUDNO.

The discussion upon Mr. Stirrup's paper read at a former meeting of the Society, upon the above subject, was resumed.

The following communication from Mr. De Rance, who regretted his inability to attend the meeting, was read:—

I have read Mr. Stirrup's paper on Llandudno with interest, having spent a month in examining the district in 1870, and having been this autumn engaged in mapping the drift deposits of the Llandudno district for the Geological Survey.

I cordially agree with Mr. Stirrup's conclusion, that the lowest glacial deposit there, consisting of a dark slaty-grey compact clay with local boulders, is the product of local glaciation, and "does not indicate an ice-sheet or *mer de glace*." I am

well acquainted with the same deposit in the line of cliffs between Colwyn Bay and the east side of the Little Orme's Head, where it rises in dome shaped masses, against which the stratified sands and gravels end off abruptly. Sometimes the sands have wedged out, and a reddish *Upper Boulder Clay*, with fragments of Lake District rocks, rests directly upon this *Glacier Till*, to which I ascribed a local origin in papers on the district, published in *Nature*, in 1870, vol ii., p. 398, and the *Geological Magazine*, vol. viii., p. 41, 1871.

With Mr. Stirrup, I regard the *Till* and its contents as originally the product of land glaciation, but I believe there is no doubt that the deposit was in part formed under water at edge of the "ice-foot," many of the fragments at Llandrillo-yn-Rhos being distinctly waterworn and dinted all over with short scratches precisely in the manner that my friend Captain Feilden saw stones scratched by the ice-foot in the Arctic regions. One of these stones, brought by him, I exhibited last week to the Blackburn Field Naturalists Society, with a stone from the Little Orme's Head, and they were universally allowed to have been scratched in a similar manner.

In my papers in 1870 and 1871, I ascribed the black Till to a somewhat older age than the *Lower Boulder Clay*, and stated that I believed the *Till* had been subjected to marine denudation before the Lower Boulder Clay was deposited, which here and there fills up the hollows excavated in the older deposit; this conclusion I have since substantiated by an examination of the whole of the ground lying between the Welsh and Cumberland mountains, and the careful study of all the sections, I have been able to find. The red clay described by Mr. Stirrup, between the Orme's Head, is, as he states, much denuded, and its position there, supposing that area were an isolated one, somewhat

obscure, but on the Colwyn Bay side of the Little Orme's Head, its place is distinctly seen, resting on the *Middle Drift* sand, and following it further east, it is seen to pass into the Upper Boulder Clay of the Flintshire coast, and the plains of Cheshire and Lancashire.

Mr. DICKINSON said he would like to ask Mr. Stirrup whether that beautiful clay used for manufacturing purposes, which was found in the neighbourhood of the Little Orme's Head was included in one of the glacial drifts; because, when he examined it some years ago he came to the conclusion that it had been deposited in connection with some mineral vein, and precisely in the same way as any mineral ore was deposited, in flats or churns.

Mr. STIRRUP said he did not, in his paper, refer to that Bay clay. He did not know, really its history; but certainly he would say it was pre-glacial. With regard to the general subject, he had a letter from Mr. De Rance, who he was glad to find, supported his conclusions fully, because they all knew that that gentleman had worked the Llandudno district thoroughly. What Mr. De Rance said, therefore, might be accepted as being pretty near the truth. With regard to the beds of mussel shells in the sand, Mr. De Rance says:—"I had always fancied the pearls were in the horse mussels, not in *mytilus edulis*." On the subject of the pearls, he thought Mr. De Rance had got somewhat astray, because pearls were not confined to any one species of shell, or indeed to any one genus, they were found in several. He (Mr. De Rance) confused them, too, by calling them "horse mussels"—a term, which, like many other popular terms, conveyed no idea as to what species was meant. Evidently, however, he was speaking of the river mussel; but he (Mr. Stirrup) was quite certain of the mussel that was in the beds at Colwyn Bay being the *mytilus edulis*.

Mr. Gwyn Jeffreys, in his "British Conchology," actually referred to that district under the head of the species *mytilus edulis*, as follows: "Great numbers are still collected at the mouth of the River Conway, in North Wales, the fish being boiled and trodden out by the naked feet of women. What is done with these 'seed-pearls' is a mystery."

The CHAIRMAN said there was no doubt that the *mytilus edulis* did ordinarily contain pearls. He had a confirmation of this a fortnight ago; he was eating a mussel, and found in it no less than eight pearls, which he preserved. They were small, ranging from the size of a pin's head up to the size of a grain of millet seed. Others occurred in the same cooking; he thought a score, at least, all small and commercially valueless, yet curious as showing that that particular species of mussel did produce pearls. He had collected during his lifetime a considerable number, which he had kept; but he never thought that they were sufficiently valuable anywhere to be worth collecting with a view to profit. He had heard it stated, before he read Mr. Stirrup's paper, that pearls had been fished for in Conway Bay. That the pearl alluded to could not have been sought for in the fresh water mussel was evident, because the Conway was a tidal river, and the fresh water mussel could not live in its estuary. If pearls had been sought for in the fresh water species, it must have been many miles up the stream from Conway Bay.

Professor DAWKINS said, with regard to the presence of pearls in various mussels, he would merely say that some had them and some had not. In the case of the oyster tribe and others, it was very much as in that of the human subject—some people suffered from a certain disease called stone, and others did not. The unfortunate mussels suffered from a peculiar stony disease, during which was

produced the stony secretion called a pearl. The number of pearls found in our rivers was one of the things said to have tempted the Romans to an invasion of this country. Pearls had been sought for in the Conway estuary time out of mind.

ON THE RANGE OF ANODONTA JUKESII.

By Prof. W. Boyd Dawkins, F.R.S.

1. Introduction.

Since Mr. Godwin Austen advanced the view that the Old Red Sandstone was a deposit of fresh water origin in land-locked areas, in 1855, its relation to the carboniferous formation has been a matter for discussion among geologists, such as Jukes, Archibald Geikie, Kinahan, and Lebour. Into this controversy I do not propose to enter. In the present communication, I merely wish to lay before the Society the occurrence of the fresh water *Anodonta Jukesii*, together with some other characteristic forms at the same horizon in the geological series, and in places very widely removed from each other.

2. Ireland.

We will begin our enquiry with Ireland. The shell was first discovered at Kiltorckan, south-east of Thomastown, county Waterford, in a yellow sandstone and in association with the remains of fishes, of crustacea and of a luxuriant vegetation. The fishes haunting the shores of the lake are well defined species found elsewhere in the Old Red Sandstone: the *Coccosteus*, *Pterychtlys*, *Glyptolepis*, *Bothriolepis*, and the *Dendrodus*. The crustacea were represented by the strange Upper Silurian and the Old Red family of

Eurypterida,—the *Eurypterus*, and *Pterygotus*. On the adjacent land was a forest composed of Lepidodendroid plants, not very different from that of the coal-measures of Lancashire. There was, however, an undergrowth of ferns, which is as yet unknown in the rocks, either above or below, of *Adiantites*, (*Cyclopteris*,) *hibernicus*, of which a frond, presented by Mr. Baily, of the Geological Society of Ireland, is on the table, and of *Sphenopteris Hookeri*.*

The physical relations of the yellow and greenish sandstone, in which these remains occur, are seen in the counties of Kilkenny and Waterford, to be as follows (Hull, Kinahan, A. Geikie,) :—

8.—Middle Coal-measures. Anthracite.
7.—Lower Coal-measures. Anthracite.
6.—Millstone grit.
5.—Yoredale shale.
4.—Carboniferous limestone.
3.—Lower carboniferous shale.
2.—Yellow sandstone. *Anodonta Jukesii, &c.*
1.—Old Red Sandstone.

Mr. Kinahan records † *Anodonta Jukesii* and *Adiantites hibernicus* from two other localities, one a mile and half east of Cork, and the other at Tallow Bridge. In both the yellow sandstone in which they are found is related to the beds below and above, as in the previous section, (No. 2.)

It is, therefore, pretty clear that the Kiltorckan fern, and the *Anodonta* mark a well defined horizon in the rocks of the south of Ireland, between the Old Red Sandstone on the one hand, and the carboniferous rocks on the other.

3. Northumberland.

We come now to the examination of the Passage beds of

* Geological Survey of Ireland, Explanation Sheets 147, 157.
† Geology of Ireland, p. 61.

the Old Red and Carboniferous in England. The research of Mr. George Tate, of Alnwich, and of other observers which have been brought together in the able papers of Professor Lebour, and since published in a separate form, reveal the fact that underneath the Millstone Grit zone of Northumberland is a series of sandstones, shells, coals, and lenticular limestones amounting to no less than 10,000 feet in thickness.* This is the Bernician series of Professor Lebour, and is the equivalent of the Yoredales and Mountain Limestone of Derbyshire, Lancashire, and Yorkshire, and of the black shales which underlie the Mountain Limestone in North and South Wales, and in Somersetshire.

Underneath this series come the shales, sandstones, and earthy limestones (cement stones), of the Northumbrian bank of the Tweed, termed Tuedian by Mr. George Tate, in 1855, which are the equivalents of the "Calciferous Sandstones" of Maclaren and the Scotch geologists, and the yellow sandstones of the south of Ireland. At the base of this series is the "Upper Old Red Conglomerate" of the flanks of Cheviots, which Professor Lebour considers to be a shore deposit of the Tuedian age.

The Tuedian beds contain a few stunted marine shells of the genus *Athyris* and *Nautilus*, and in a fine grained hard sandstone in the upper part of the series *Anodonta Jukesii* was identified by Mr. Richard House in 1877. Associated with it were the remains of *Ulodendron ornatissimum* and other lepidodendroid plants, and of calamites. The relation of the Tuedian series to the coal-measures generally of Northumberland, is shown in the following section, in which the numbers are the same as those in the preceding section of the South Irish strata:—

* Letter of Professor Lebour to me, April 23, 1881.

NORTHUMBERLAND.

LEBOUR AND HULL.

9.	Upper coal-measures	900
8.	Middle coal-measures	2,000
7.	Lower Coal-measures	150
6.	Millstone grit and shales	414
5, 4, 3.	Bernician limestones, shales, sandstones, coals	=10,000
2.	Tuedian sandstones, shales, earthy limestones, conglomorantes ..	

It may be remarked that the *Adiantites hibernicus* has been discovered in the yellow sandstones of the South of Scotland (A. Geikie, Jukes' Manual, p. 568), and that it occurs in Devonshire in the Middle Devonian strata of Morte, and in the Upper of Baggy (Etheridge, Quart. Jour. Geol. Soc. xxiii., p. 616).

4. THE STATE OF NEW YORK.

Nor are we without evidence that the *Anodonta Jukesii* and the *Adiantites hibernicus* are represented in the United States, in the upper portion or the passage beds of the Old Red Sandstone, by two forms, which I had the pleasure of examining in the collection at Columbia College, New York, under the guidance of my friend Professor Newberry. The one *Anodonta* (= *Cypricardites catskilliensis*, Hall) occurs in the Catskill rocks, and, according to Professor Newberry, is of carboniferous age; while, according to Professor Hall, the strata containing it lie below the Chemung and lower portion of the Hamilton group, and are therefore upper Devonian.

The other, the fern *(Cyclopteris Jacksoni)* Dawson, comes from the Chemung and Catskill rocks which, according to Professor Newberry, form the base of the Carboniferous Rocks of United States. I was unable to distinguish these

two forms from the Irish specimens on the table, and if they are not specifically identical, they are, in my opinion, merely geographical varieties. The fern, however, is considered by Professor Newberry specifically distinct from the Irish species; but he has not had the opportunity of examining the fine series of fronds in the Manchester Museum.

5. General Conclusions.

Thus we have evidence that the *Anodonta Jukesii* was living in the fresh waters of Ireland, Britain, and the United States, and that the *Adiantites hibernicus* grew in the sombre Lepidodendroid forests of Northern Europe and North America, after the deposit of the Upper Old Red Sandstone properly so called, and before the accumulation of the lower carboniferous shale of Ireland on the Bernician shale of Northumberland. Whether the rocks in which they occur are to be classified with the Carboniferous, or with the Old Red formation, appears to me an open question only to be solved by a more careful enquiry into the fauna and flora than has yet been carried out.

It is a matter of no small interest to note that the *Anodonta Jukesii* is the first fresh water shell as yet discovered in the rocks, and that since the time when it lived in the lakes and streams of the northern hemisphere, the form of the shell has scarcely changed. It is so like the common Anodonta of our streams that if the latter were in the fossil state it would be hard to distinguish the Kilorchan fossil from the living species.*

Mr. Stirrup said that it was gratifying to be able to correlate rocks so widely separated as those to which Professor Dawkins had called their attention. It appeared

* I have to thank Professor Newberry for much valuable information relating to the American Anodonta and fern, and Professor Lebour for

to him that the circumstances mentioned afforded good data for detecting rocks belonging to the coal measure series. He was not at all aware that in Northumberland they had the *Adiantites*, nor was he aware of the *Anodon Jukesii* having been found there. Its presence in that locality seemed to him to be of great classificatory value. Specimens of the Irish fern he had before seen, and he thought there were much larger and finer fronds now to be seen in Dublin than in the specimen now exhibited by Professor Dawkins, and which the Owens College was so fortunate as to possess. It tended to show, moreover, that the climatic conditions at the time when the fern and the *Anodon* lived contemporaneously, were of the same character over a large extent of the earth's surface.

Mr. DICKINSON said it was interesting to have beds situated at such great distances from each other, as those in Northumberland and County Waterford, brought together. The paper did not specify in what part of Northumberland the fossils were found, but from his knowledge he should suppose they were found in the western part of the county, the eastern part being the lower coal measures and the limestones.

Professor DAWKINS: It is in the western part.

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his kind assistance in dealing with the Geology of Northumberland. The following are the principal authorities used in the preceding paper:—

Baily, W. H.—*Figures of characteristic British Fossils, Vol. 1.*, 1875.

Geikie, A.—*Trans. Bir. Soc. Edinburgh.* xxviii. 345.

Geikie, A.—*Jukes' Manual of Geology.*

Etheridge.—*Quart. Genl. Journ. Lond.* xxiii. p. 568, et seq.

Kinahan.—*Geology of Ireland.*

Hull.—*Coalfields of Great Britain.* 4th edition.

Lebour.—*Outlines of the Geology of Northumberland.* 1878

Geol. Mag. Dec. II., Vol. 4, No. 1. "Bernician and Tuedian."

Proceed. N. Engl. Inst. Mining and Mech. Engin. xxv. "Larger Divisions of Carboniferous System in Northumberland."

Mr. Dickinson said, as to the coal measures of Northumberland being correlated with the middle measures of Lancashire, that he thought was a pure mistake, which some Northumberland and Durham engineers held. There was not a single seam, as far as his knowledge went, that came up as far as the Arley mine. They were in the lower coal series. He would be glad to hear some explanation given of the change which had been made, recently, in the Geological maps of the South West of Ireland: formerly they had the old red sandstone there, but now the greater part of those rocks where the principal metalliferous mines lay, are represented by the Geological survey as being of very much older date than the old red.

The Chairman said that Professor Dawkins had been upon ground that day which had formed a geological battlefield for some years past. The battle was one in which all the noted geologists—Kinahan, Hull, and also Jukes, in his time—had taken part; and he did not know that they had yet come to any conclusion as to the age of those various rocks in that locality. Who would succeed in solving the difficulty; whether Mr. Kinahan, Professor Hull, or some other authority, it was impossible to say.

Mr. Dickinson said he would like to add to his remarks that from the lithological character of the rocks in which the metalliferous mines in that part of Ireland lay, he had do doubt that they were much older than the Old Red Sandstone.

Professor Dawkins said, with regard to the "battle field," he thought he had sufficiently guarded himself by saying that he entered it, but took no part in the fight, and just walked away from it. He thought the meeting would have gathered from his paper that precisely the same battle was being fought in the United States, and that Professor Hull on the one side, and Professor Newberry on

the other, were repeating the battle between Jukes on the one hand, and the majority of English geologists on the other. The fight related to the same series, in which those fresh-water shells and the fern *Adiantites hibernicus*, occurred; and, indeed, as far as geological classification went, it was "six of one and half-a-dozen of the other." It did not make any difference whether they classified these beds with the Carboniferous series above, or with the Old Red below. With regard to the other point, to which Mr. Dickinson alluded, he quite agreed with that gentleman that the metalliferous rocks in the South West of Ireland were much older than the Old Red Sandstone; indeed, the explorations of Drs. Hunt and Hicks, have shown conclusively that the rocks of the west of Ireland were Precambrian or Archaian, like the rocks of the west of Wales and the west of Scotland, being the oldest of the stratified rocks—twisted, folded, and altered by intense heat, and presenting to us the very base of the fragmental series.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XII. VOL. XVI. SESSION 1881-82.

At the ORDINARY MEETING of the Members of the Society, held on Friday, the 6th day of January, in the Council Chamber, Municipal Buildings, Wigan;

GEORGE GILROY, Esq., M.INST.C.E., President, in the Chair.

Mr. R. Archibald Sacré, Mining Engineer, 20, Cooper Street, Manchester; was proposed, balloted for, and duly elected an ordinary member of the Society.

The following are the additions to the Library, since the last Meeting:—

The Canadian Institute: Transactions, Part 1, Vol. I. New Series.—*From the Council.* The Epping Forest and County of Essex Naturalists' Field Club: Transactions, (Oct., 1881,) Part 5, Vol. II.—*From the Council.* The Free Public Library (Reference Department), Sydney: Supplement to the Catalogue, for 1877 and 1878.—*From the Committee.* The Geologists' Association: Proceedings, No. 3, Vol. VII.—*From the Council.* The Geological Magazine, No. 211.—*Purchased.* The Hertfordshire Natural History and Field Club: Transactions, Parts 5-7, Vol. I.—*From the Council.* The Iron and Steel Institute: Journal, No. 2, 1881.—*From the Council.* The Mining Institute of Scotland: Transactions, Part 9, Vol. III.—*From the Council.* The Museum of Comparative Zoölogy, Cambridge, U.S.A.: The Annual Report of the Curator, 1880-81.—*From Alexander Agassiz.* The North of England Institute of Engineers: Transactions, Part 5, Vol. XXX.—*From the Council.* The Nova Scotian Institute of Natural

Science: Proceedings and Transactions, Part 3, Vol. V.—*From the Institute.* The Owens College: Calendar, Victoria University, for Session 1881-82.—*From the Principal.* The Royal Geological Society of Ireland: Journal, Part 1, Vol. VI. New Series.—*From the Society.* The Royal Society: Proceedings, No. 216, Vol. XXXIII.; and List of Fellows, Nov., 1881.—*From the Society.* The South Wales Institute of Engineers: Proceedings, No. 7, Vol. XII.—*From the Institute.* L'Académie Imperial de St. Petersburg: Mémoires, VII. Serie, Nos. 8 and 9, Tome XXVIII., and No. 1, Tome XXIX.; Bulletin, No. 3, Tome XXVII.—*From the Academy.* R. Accadamica dei Lincei: Transuntis, Vol. VI., Fas. 2°.—*From the Academy.*

EDWARD WILLIAM BINNEY, F.R.S., F.G.S.

Was born at Morton, in Nottinghamshire, in 1812; and died in Manchester, on the 19th of December, 1881. Mr. Binney came to reside in Manchester in 1836, and having strong scientific tastes, devoted himself, in the intervals of his professional engagements, to the geology of this district. In 1838, he formed one of a band of scientific workers, and in October of that year, the Manchester Geological Society was founded; the late Lord Francis Egerton, M.P., F.G.S., being the first President, and Messrs. E. W. Binney and J. F. Bateman the first Honorary Secretaries. The first article, "On some of the Objects and Uses of Geological Researches," was read by Dr. Black, whose son has recently been elected a member of this Society. Mr. Binney contributed the next article, a "Sketch of the Geology of Manchester and its Vicinity," illustrated by three coloured sections, and out of the eleven published articles in the first volume of the Society's Transactions, he contributed four. Mr. Binney was President in 1857-59, again in 1865-67, and on the 25th of October last year (1881), presided at the Council Meeting, preceding this Society's Annual Meeting. This was the last time our members met him, and at his funeral the President, Vice-Presidents, Honorary Secretaries, and Council paid their last respects

to his memory as an old and valued friend and one of the founders of the Society. Appended is a list of his published papers, contributed and published in the Society's Transactions:—

"Sketch of the Geology of Manchester and its Vicinity," illustrated with three sections, part 1, read Feb. 7, 1839.
Ditto ditto part 2, read March 7, 1839.

"Observations on the Lancashire and Cheshire Coal Field," with a section, read October 31, 1839.

"Remarks on the Marine Shells found in the Lancashire Coal Field," read March 26, 1840.

"On the Fossil Fishes of the Pendleton Coal Field," largely illustrated, read October 29, 1840.

"Notes on the Lancashire and Cheshire Drift," read December 22, 1842.

"On the Petroleum found in the Down Holland Moss, near Ormskirk," by Messrs. Binney and Talbot, read March 30, 1843.

"On Sigillaria and its Roots," read December 7, 1858.

"On the Lancashire and Cheshire Drift," read April 5, 1859.

"Account of the Geological Excursion in the Neighbourhood of Manchester," May 3, 1859.

"Account of the Excursion to the Burnley Coal Field," February 16, 1860.

"Account of an Excursion to Brooksbottom and the Neighbourhood," May 9, 1860.

"Observations on the Fossil Shells of the Lower Coal Measures." read April 24, 1860.

"On a Crystal of Selenite, found in the 'Till' in North Cheshire," read November 20, 1860.

"Observations on Down Holland Moss," illustrated by a map and sections, read November 20, 1860.

"On a Non-blazing Peat, found at Churchtown," read December 18, 1860.

"Remarks on an Erroneous Statement respecting Fire-damp," read January 29, 1861.

"On the late Mr. Elias Hall, the Geologist." April 30, 1861.

"On the Drift Deposits found about Llandudno," read April 30, 1861.

"On Sigillaria and its Roots," read May 28, 1861.

"Account of an Excursion to Todmorden," May 7, 1862.

"Geology of Manchester and its Neighbourhood," with sections, read June 24, 1862.

"Account of an Excursion to Halifax, Low Moor, &c.," September 3, 1862.

"On the Dyas or Permian Formation in England" (translated from the works of Dr. Geinitz, of Dresden), read February 24, 1863.

"On the Geology of Manchester," read May 19, 1863.

"Remarks on Locks for Davy Lamps," May 19, 1863.

"On the objects of the Manchester Geological Society, and the best means of attaining them," President's Address, November 28, 1865.

"On the Upper Coal Measures of England and Scotland," read December 18, 1866.

"On the Permian and Triassic Strata of the North-west of England and the West of Scotland," read December 18, 1866.

"Notes on the Excursion to Disley," April 15, 1867.

"Remarks respecting the Position of the Society," October 27, 1868.

"Description and Specimens of Bituminous Shales from New South Wales," February 28, 1871.

"On a Section at Blackstone Edge, through which the Summit Tunnel is cut, on the Manchester and Leeds Railway," read March 25, 1873.

"On the Permian and Trias Strata," read March 31, 1874.

The CHAIRMAN said it was his painful duty to call the attention of the meeting to the great loss the Society had sustained since the last meeting in the death of Mr. Binney, who was one of the founders, and had up to the time of his death been a member of the Society. He was a most zealous and hard working man in the cause of science, and for upwards of forty years had occupied a distinguished position in the scientific world. The Society was represented at his funeral, and every mark of respect was paid to his memory. He had known Mr. Binney for many years, and had often heard it stated that he was considered to have the best knowledge of the coalfields of Lancashire and Cheshire, and the geology of the whole district. Under the circumstances he thought it would well become them to pass a vote of condolence with the widow and family of Mr. Binney, and he proposed that such a resolution be passed.

Mr. BRYHAM said he had much pleasure in seconding the vote of condolence. He had had the honour and pleasure of knowing Mr. Binney for many years, and he fully concurred in all the President had said with reference to his great knowledge and ability in connection with the coalfields and geology of this district.

The motion was agreed to unanimously.

A NEW EXPLORING RESPIRATOR.

Mr. MARTIN said he had been requested to read some notes with regard to an apparatus which had been of use, and did some very good work at Seaham Colliery in the opening out of the Maudlin seam after the disastrous explosion which occurred there. The apparatus is one patented by Messrs. Forster and Fleuss, and consisted of of an arrangement by which the air was filtered, and after being purified with pure oxygen was taken into the lungs.

A flexible mask covered the face, and tubes were provided for inhaling and exhaling the air. The lamps were self-contained and portable. They would give a brilliant light for four hours in water, or the most inflammable gas, without any chance of extinction, or of explosion. The apparatus had been successfully used at Burton-on-Trent as well as in the Seaham Colliery. The Maudlin seam in the latter colliery had remained closed for eight months after the explosion of 1880, in consequence of a large fire existing in the stables. The air during that time was totally excluded, the seam being hermetically sealed. At the end of eight months one of the stoppings was broached, and the workings were found to be full of fire-damp. It was, therefore, necessary to clear the workings to the seat of the fire with brattice. The patent breather and lamp enabled the men employed to penetrate a considerable distance in advance—in one instance upwards of 300 yards—to examine the state of the roads, which were filled with gas. In putting up the brattice the lamp was of the utmost service, and the men were frequently enabled to continue at work when it would have been totally impossible to do so if the ordinary safety lamp had been used. Usually the gas was taken from London compressed in wrought iron bottles, but at Seaham, as there was so large a quantity required, it was decided to make it on the premises. The apparatus, in addition to being of use in mines, would be available in case of fire on board ship, and for examining ship bunkers.

The Chairman remarked that probably the invention might be extended to many other things besides collieries, such as large mills, manufactories, and theatres, in case of fire.

Mr. Martin added that he had hoped Mr. Fleuss would have been present to exhibit and explain his apparatus, but another engagement prevented his doing so.

NEW FAN INDICATOR AND TELL TALE.

Mr. Henry Hall, H.M. Inspector of Mines, exhibited and explained a new Fan Indicator and Tell Tale, invented by himself. It was, he observed, most important that some automatic apparatus should be attached to all fans to indicate their speed at all hours of the day, and that, if possible, each apparatus should be so placed as to be out of the reach of any interference or tampering on the part of the officials upon whose attention to duty the instrument was intended to act as a check. He believed the presence of such an apparatus would ensure greater watchfulness and care from engineers in charge of ventilating engines. The Tell Tale which he had brought before them was an inexpensive and simple, yet effective method of securing this end. It could be fitted up in a few hours by any ordinary colliery mechanic, and one of these appliances had been already attached to the large Guibal fan at the Bickershaw Colliery, near Wigan, where, he believed it gave perfect satisfaction The apparatus consisted of a specially designed water-guage glass, which was fixed in the manager's office, and leading from this to the fan engine house—a distance, at the Birkenshaw Colliery, of 200 yards—was a range of ¾in. iron pipes the open end of which was placed within the fan drift; then a short branch of similar piping was joined to these, and the open end placed in the fan engine house, where it was fixed so as to be within reach of some moving part of the engine that drove the fan—the pipe end at Bickershaw being within reach of the motion of the valve spindle. A small lever was next attached to this pipe end, with a movement up and down, so as to open and close the outlet of the pipe, and the motion of the spindle played against this, so that at each stroke of the fan engine the pipe end is opened

for an instant, and a variation in the pressure of the atmospheric air in the long branch of pipes takes place, causing the fluid of the gauge glass in the manager's office to fall to zero; but immediately the pipe end is again closed by the falling lever, the water-gauge glass shows the drag on the water-gauge of the mine, and the result was a perfectly correct and constant indication of the drag of the mine, and also of the number of revolutions the fan was making. This indication taking place in the manager's office, where it could be registered in a book as often as might be convenient, was entirely out of reach of any interference on the part of the person responsible for the speed of the fan. The fluid in the gauge glass fell to zero at each stroke, so that it was only necessary to count these movement in the glass to determine the speed of the ventilating engines, and the height of one leg of the fluid over the other between the strokes was the measure or water-gauge of the mine. Where the fan to be indicated travelled at a great speed, each fifth stroke only was dealt with, so as to allow sufficient time to read off the drag of the mine between the indications of the speed, and this was effected by the introduction of two small wheels working at five to one, and deriving their motion from the drag crank of the engine. The cost of the apparatus did not exceed three or four pounds, unless the distance between the manager's office and the fan was very great; but, so far as regarded the efficiency of the appliance, distance was immaterial, as it had been tested up to 800 yards. For those who are anxious that the indications should be permanently registered, an eight-day clock could be added, which was fitted with a revolving brass cylinder, carrying a diagram paper, upon which a spiral line was drawn by a pencil, indicating the number of revolutions by the fan and the water-gauge during any and every hour of the day or night.

In answer to Mr. MARTIN,

Mr. HALL said the indicator he had described had been in use at the Bickershaw Collieries for several months. There were some indicators which only indicated in the engine-house, but he had tested the one of which he spoke at a distance of 750 yards from the pit.

Mr. MARTIN observed that at the Townley Colliery there was a self-registering instrument in use.

Mr. HALL said he had seen one at present in use, which had cost about £30, but the difference between that and the one he had described was, that the former only indicated in the fan engine-house where the man was in charge, while the latter indicated at any distance from the fan.

THE NEW TIN-CAN SAFETY LAMP.

Mr. HALL next exhibited and described "A new Tin-Can Safety Lamp." He remarked that no doubt everyone present knew that the most elaborate tests had been carried out lately for the purpose of discovering whether the present so-called safety lamps were really so or not. There had been a long series of experiments at Bryn, which, no doubt, many who were present had witnessed, and some years ago there was also a long series of experiments at Hetton Colliery, in Durham, and another in Belgium, All those experiments seemed to prove incontestably that the so-called safety lamps at present used were safety lamps only in name. The days of their old friend, the Davy lamp, seemed to be numbered, but he was happy to be able to produce a Davy lamp improved in such a way that according to the experiments to which he had just referred it appeared to be the safest lamp that could be obtained. This lamp he was told had been subjected to the test of 1,800 cubic feet of explosive mixture per minute passing upon it, and it had

also been tested in other ways, but during the whole of the experiments it had never been found to fail. It was an ordinary Davy lamp put into a tin case with a piece of glass let into the front of it. There was a lock on the case so that the lamp was double-locked. The shield which the Tin-Can formed not only prevented any atmospheric current having effect on the lamp, but seemed to be a great guard against injury to the lamp itself, as a man might strike the case a hard blow with his pick point, and the chances would be that the lamp would escape injury. There was a second form of lamp with glass let in all round it instead of glass only on one side, but he preferred the one with a small pane of glass in front, the advantage being that the tin never got hot. So far as draught was concerned, he had tried the lamp down the Abram Colliery in some of the places where there had been falls, and where a tremendous draught was blowing, and the wind did not seem to move the light in the least. So far as he could learn the lamps were being introduced by thousands into the collieries of Durham, and they were now in use at Seaham, Ryhope, and also, he believed, at Hetton Collieries. He hoped that the Lancashire people, if they approved of the lamp, would not be slow to adopt it likewise. He did not know that anyone could lay claim to the invention. There were two or three men in Durham who said they believed they were the inventors, but there seemed to be great doubt on the subject. It seemed as if some boys, finding it difficult to keep the ordinary Davy lamp alight in a strong current of air, had contrived a shield to surround it, and preventing the draught getting to it thus to keep it burning.

The lamps were then handed round, and minutely inspected.

Mr. Smethurst said before they passed away from the subject of the Tin-Can lamp, he should like to say some-

thing with regard to it, and, in expressing his opinion, he was sure Mr. Hall would not consider him out of place if he cast some little doubt on the value of the lamp. Mr. Hall had observed that the lamp was a safe lamp. Under certain conditions it was, but it was a mistake to suppose that it had never been known to fail. It had been known to fail when the ventilating holes in the lower part of the Tin-Can were placed too high up. If these holes were made as high up as the gauze, the current of air had just the same result as if the lamp was out of the case. There was also an objection to the lamp on another account. The dust got down between the gauze and the casing and covered the glass, which was not very large, and so the light given out was considerably reduced. He could not say this was the only safe lamp that had gone through the experiments referred to by Mr. Hall. Other lamps, such as the Muesler, if made in a proper form, would undergo the same tests. Still, to put a Davy lamp in a case of this sort rendered it, comparatively speaking, a perfectly safe lamp, if care were taken that the holes were not too high up. If they took an ordinary Mueseler, or any lamp which required feeding from the gauze downwards, and, instead of putting a single disc for the chimney to rest upon, made a double disc, they produced a lamp as safe as the Tin-Can lamp and giving five times the light. The objection made to the Mueseler was that if held on one side it went out. If anyone could accept this as an objection he should be sorry for them. If the light could get against the glass by holding the lamp on one side it was as unsafe as the Davy lamp, and, therefore, instead of being an objection, the fact that the light went out when the lamp was held on one side was an advantage. The collier would try by some means to open the tin lamp in order to clean the glass. There was, in his opinion, no objection to having glass all round if there

was any guarantee that it would not be broken, especially as the light would otherwise be reduced to a very great extent. Something, certainly, ought to be done to improve the lamps at present in general use, considering how unsafe they were. The sooner the Government or they themselves took up the matter the better it would be. He thought the Government ought to do something on the subject, as a colliery proprietor could not adopt a new form of lamp in his pit and insist on the men using no others, without having some of the men saying they would go to pits where they could use their own lamps. What was wanted was for the Government to say which lamps were to be abandoned, not that they should say which lamps ought only to be used, and safer lamps would then at once come into general use. The Davy in its old form was at present used in half the collieries of the district, and if they would take into consideration for how long a time the Davy was safe in an explosive mixture, they would agree with him that something ought to be done. In a current of 1,000 feet velocity the present Davy lamp was safe for not two seconds. It must also be remembered that, from actual experience, opinion had considerably altered as to the amount of gas required to form an explosive mixture. It was formerly considered that 12½ per cent. of gas formed an explosive mixture, but it was now found that 3½ per cent. was quite enough, and, with dust, 3¼ per cent. If they took into consideration what a small quantity of gas was required to cause an explosion, it should be the means of bringing them to their senses and impelling them to introduce lamps which were perfectly safe. For instance, when walking against a 400ft. current they created a velocity of 800ft., and only a small quantity of gas was required to cause it to explode. The meeting ought to be obliged to Mr. Hall for bringing forward the subject. The

step he had taken was in the right direction. The Tin-Can lamps had been subjected to very severe tests, and the only way they could fire them was by placing the ventilating holes too high up. As long as these holes were kept low enough down they could take such a lamp into any atmosphere or any current without fear.

Mr. W. Pickard, who spoke from the point of view of the practical miner, observed that there were two or three objections to the Tin-Can lamp. In the first place, the Davy lamp was secured from the observation of the miner, and he could not possibly examine it except through the glass. Accumulations of dust would also take place inside the case, and thus would lessen the light to some extent. He hoped in their desire for improvement they would also have a view to usefulness. The Davy lamp was quite dark enough to put into the hands of the workman, without adding further complications and diminishing the illuminating power. What was wanted was a safety lamp which would in the first place prevent a man working in gas, and in the second give him light. In these days of the weighing clause and the request of the public for clean coal, they ought to afford the miner the fullest opportunity possible for sending clean coal to the surface, whereas, if they diminished his light, he would not know whether he was sending up coal or dirt. One of the difficulties connected with the Tin-Can lamp was, that when, owing to the occasional oscilliation of the lamp, oil was spilt upon the gauze, this fact could not be discovered, and serious results might ensue. The Davy was certainly not safe, and he would advocate the adoption of some lamp in which the light would be extinguished immediately on coming in contact with gas, and that in the Mueseler, or the Mueseler Protector, you have got such properties required.

Mr. C. F. Clark said he thought their attention should

be directed to finding a lamp which could be made to go out immediately it came into the presence of gas. He did not believe any lamp was safe in an explosive mixture. However perfect the lamp before them might appear in their experiments, they all knew the great dangers and difficulties they had to contend with in the mine, and it was, therefore, to be preferred that the lamp they carried should be extinguished as soon as it came into contact with gas rather than that they should continue half the shift with a lamp filled with explosive gas. Such a lamp as he had pointed out would satisfy the workmen very much better than any other description.

Mr. W. Topping said he had long been of opinion that the Davy lamp with a circular shield was the simplest and safest lamp produced. Having had that view for some years, he had introduced them into their most fiery mines. When they were first introduced Mr. Pickard's attention was drawn to them, he being at that time the agent of the miners. The men had a great objection to them simply because the light was not concentrated, as in the case of lamps with only a partial shield. There was a back light, and for that reason they did not like it. Another objection to these lamps had been the liability to breakage of the glass; but if it could be proved that the ordinary Davy lamp placed in a tin can could give out as much light as the unprotected Davy, he should certainly say it was by far the most suitable lamp yet invented. His views on this subject differed very much from those of Mr. Clark. A lamp was intended for light, and that which went out in the presence of gas was defective in itself. They wanted one capable of determining the nature of the atmosphere, and at the same time one that would enable them with safety to walk out of the danger. Mr. Smethurst and Mr. Pickard had spoken of the objection arising from accumu-

lation of dust between the Tin-Can and the lamp, but he had not found as yet this to be so. With the view of testing what current was likely to affect the lamp, he had allowed the full force of all the air coming down the pit to come in contact with the lamp, and the result had been to convince him that in any hurricane it would live.

Mr. TEALE, inventor of the Protector lamp, said his opinion of a good lamp was that it should give a good light, and that it should go out when it came in contact with gas. He had no hesitation in declaring that collieries could be lighted with perfect safety. The thing was only a question of getting rid of some primary difficulties, and the great difficulties to be encountered were custom and prejudice. As regards tests it was very important that the tests should be made under similar conditions, which he was afraid was not often done. He had seen a Davy lamp remain in a current of explosive mixture having a velocity of 15 feet per second, 20 minutes after the gauze was red hot, but immediately the ventilation was checked the lamp went out. He did not believe the lamp before them was as safe as they imagined. Personally he should like to know the condition of the test it had undergone.

Mr. SMETHURST said it was utterly impossible for a Davy lamp to stand in a 1000 feet current above four or five seconds without exploding. The new Tin-Can lamp did not go out in the presence of gas. It was fit only for underground managers in their examination of the mine, but it would not do for the collier, for he could neither see to work properly, nor to clean his coal, and they might have many more accidents, which would be attributed to the want of light.

The further discussion was adjourned till the March meeting when a paper will be read on safety lamps and their discussion appropriately resumed.

LONG-WALL AT THE SOVEREIGN PIT, WESTLEIGH.

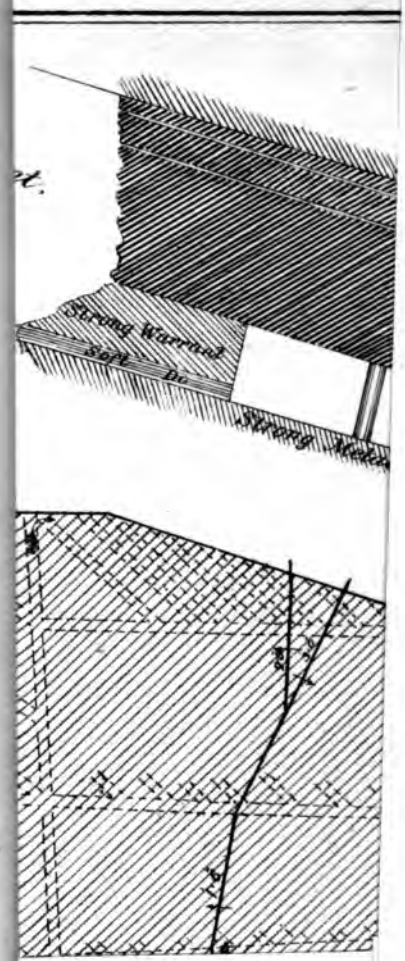
Mr. James Hilton, of the Wigan Coal and Iron Company, Limited, read a paper on "The Long-wall System adopted in getting the Wigan 6ft. Mine at the Sovereign Pit, Westleigh." Before describing the mode of working, Mr. Hilton said it might, perhaps, be of interest to state that the 6ft. coal at the Sovereign Pit was won in December, 1877, at a depth of 373 yards, and found to be 5ft. thick. The diameter of the shaft is 18ft., and the strata was sunk through without any serious or fatal accident in twelve months. This immunity from accident was, no doubt, due to the advanced appliances introduced for the safety of those engaged in the sinking operations, and with reference to these he might specially mention the arrangement of rope guides and scaffolds, both of which, in his opinion, added to the safety and also expedited the work. The sump was carried 17 yards below the main coal and a thin seam of coal was struck, which was found to be very gaseous. The shaft being completed, it was decided for ventilating the mine, to erect on the surface a large Guibal fan, as this was considered somewhat better than an underground furnace. In opening out the mine, 24ft. mouthings were cut, and levels 12ft. wide were commenced east and west on the 2nd July, 1878. Whilst these were being driven abundant proof was afforded that the mine had at least one of the unfortunate characteristics found, in what might be termed the deep portion of it, in the neighbourhood of Wigan, he referred to the large quantity of fire-damp given off. Knowing the number of disasterous explosions which had taken place in the Wigan 6ft. mine led to the question whether pillar and stall—the only mode of working

this seam in the Wigan coal field at that time—or long-wall working should be tried. After considerable discussion it was decided that the last-named system should be adopted, and so soon as such distance had been driven as to give a sufficiently large shaft pillar (100 yards being left for this purpose) they commenced working the seam on the "end" by long-wall. In the meantime a long-wall "face" was tried on the east side, drawing roads being carried in a level direction 10 yards apart. Holing was tried in the dirt under the coal, but it was soon found to be too hard, owing to the coal in the middle of the seam being tender and giving way before the dirt. It was consequently given up, and the bottom part of the coal was holed in. This necessitated blowing up the floor in the main level in order to obtain packing material. As this was insufficient, dirt had to be conveyed from other parts of the mine, which proved to be very expensive; in addition, the results as to round coal were unsatisfactory, not more than 50 per cent. being obtainable, while the cost for prop wood was also heavy, not being less than 3d. per ton. Face long-wall was consequently abandoned, and the present method of end long wall was started. After the upbrows had been driven the required distance a pair of levels 15 yards apart was cut through to each of the brows. The level pillar was then taken out, and a drawing road was then taken in the middle of it. While this was going on a ten yards ribbing was taken off the higher side. Packing dirt was got by blowing up the floor in the drawing roads and a place about three feet wide on the higher side of the ribbing. The latter formed a base of operations for subsequent holing and as the removal of the dirt in the latter place advanced, men followed up with holing six feet beneath the solid coal, setting spraggs four feet apart. This continued until there was a face of 300 yards long, short drawing roads being left

at intervals of ten yards as the work progressed. No chocks were set in any of the roads, and very few props or bars were required. The holing being finished, the officials removed the spraggs, the coal falling as they were withdrawn ready for removal by the colliers. This being done, front spraggs were again set, holing resumed as before, and the operation was repeated from time to time, the face gradually advancing until, at a distance of 100 yards from the starting level, the first long rupture of the overlying strata took place. This, however, produced no serious inconvenience, very few of the working places being affected, and so far as could be seen the following morning, no emission of gas proceeded from the fracture, which was about seventy yards in length. As the work progressed the holing dirt was found to vary in thickness from 18 inches to 37 inches, and the distance between the drawing roads had to be increased or decreased in order to get requisite storage room, ten yards being the distance when the holing was about two feet, and 15 yards when it was three feet or upwards. Very little blasting was required in the mine; none, in fact, being necessary, except where owing to dislocation of the strata, or serious thickening of the holing dirt, it was necessary to break down into the latter from the top instead of as in the ordinary way holing under the face of the coal. In consequence of the roof being so well packed no place was left for gas, and it settled down more regularly, taking about 18 months to press the packing sufficiently so as to resist any further downward movement. In fact, about 100 yards from the face the roof became quite settled, and required no timber. For ventilation no brattice was required at the face, the air being carried up the east and west jig brows along the face, and returning down an airway at each end of the workings. The yield of round coal over a

⅝inch screen was 80 per cent. as compared with 50 per cent. by pillar and stall working under similar circumstances. The cost of prop wood did not exceed ½d. per ton at the face, and the cost of labour might be given as under:—Holing, filling, and taking coals to the shunt, &c., 1s. 6½d. per ton; packing places and keeping drawing roads in order, 8d. per ton, while other labour was not necessary to take into consideration, as it is common to both long wall and pillar and stall systems. In conclusion, he might state that in order to liberate the gas from the thin fiery seam struck underneath the six-feet in sinking the sump hole bore holes were occasionally put down, and from some of these holes gas was discharged at a pressure of 10 to 15lbs. per square inch for some time after the coal was struck. This gas, however, was only liberated by the officials after the workmen were out of the mine, and as an additional precaution the Mueseler safety lamp was exclusively supplied to the colliers, the Davy lamp being reserved solely for the use of the officials.

The discussion on the paper was adjourned until the paper is in the hands of the members.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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIII. VOL. XVI. SESSION 1881-82.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 7th day of February, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

GEORGE GILROY, Esq., M.INST.C.E., President, in the Chair.

NEW MEMBERS.

The following gentlemen were proposed, balloted for, and duly elected ordinary members of the Society:—

F. LEWIS BRADLEY, Bel-Air, Alderley Edge;
GEORGE CLARK, Mining Engineer, Newton-le-Willows;
CHARLES COCKSON, Mining Engineer, Wigan Coal and Iron Company, Wigan;
ROBERT GREENHALGH, Engineer, Atherton, near Manchester;
WILLIAM HEATHCOAT, Farnworth, near Bolton;
WILLIAM JOHNSON, Abram Colliery, Wigan;
GEORGE KENNY, Surveyor, 11, King Street, Wigan;
ISRAEL KNOWLES, Wigan;
CORNELIUS M. PERCY, F.G.S., M.I.M.E., King Street, Wigan;

WILLIAM RIGBY, Mining Engineer, Leader's Buildings, King Street, Wigan;
JOEL SETTLE, Darcy Lever Collieries, Bolton;
THOMAS R. STOPFORD, Colliery Manager, Park Hall Colliery, Blackrod, Lancashire;
EDGAR STOREY, Mining Engineer, Leigh, Lancashire;
THOMAS ASHCROFT WALKER, Pagefield Iron Works, Wigan;
HENRY WALL, Surveyor, 11, King Street, Wigan.

THE KŒPE SYSTEM OF COLLIERY WINDING.

BY C. M. PERCY, F.G.S., M.I.M.E.

The most important mechanical appliance at a colliery is the winding engine. However deep the shaft, every pound of coal got has to be raised, all materials going into the mine have to be lowered, and all the persons employed underground have to be sent in and brought out once in every day by the winding engine. A winding engine, in consequence of the intermittent action, is not one with which economical results were usually obtained, and the general tendency of late years had been to have winding engines which were, by their very principle, extravagant in the consumption of fuel, the one aim being to have a powerful engine, quick in working, and easy of control. Of course, no winding engine is worth adoption in this advanced period of colliery engineering that lacks these qualifications, but this is not everything, and something should be done with regard to economy. The argument has been often used that there is no real waste with colliery engines, because, however much fuel they use, it represents no value, and would have to be thrown away if not used. Such an argument is nonsense, because, in any case, the fuel that generates steam for a

colliery engine could be sold to generate steam at a mill or a foundry. And fuel has now to be raised from such a depth that even the slack should represent a commodity of some value. And it must be remembered that not only does each ton of slack thus saved mean a few shillings more of profit for the colliery, but if less slack is used to generate steam, fewer boilers will be needed, and there will be less manual labour, all of which amounts to so much hard cash—which, in periods such as that through which, let us hope, we have almost passed, had better remain in the pockets of the colliery proprietors. There seem to be two principal directions in which efforts might be made for effecting economy in winding engines. First, by the application of condensers. We, in Lancashire, have for many years practically turned our backs upon condensing winding engines, and have gone in almost universally for high pressure non-condensing engines, and although in this country we possess the very best examples of this kind of engine they are very expensive to work. In the North of England in many cases, the spirit of James Watt possesses the minds of engineers, and within the last few weeks the writer was fortunate in seeing at work a winding engine with condensing arrangements and doing good work. To raise 1,800 tons of coals from a depth of 600 yards and to lower and raise 1,000 men and boys, all within twenty hours, is good work for any engine at any colliery; but to do this with steam never above 20 lb. pressure from four externally fired boilers, each 7 ft. diameter, is a result not surpassed at any colliery with which the writer is acquainted. The actual useful horse-power performed is nearly 100 tons per hour, raised 600 yards, equal 200-horse power. Four boilers, each 40 ft. long and 7 ft. diameter, may be taken as equal to generating steam equal to 800-horse power if worked at a moderately high pressure of 60

or 70 lb. And to obtain with a working pressure never exceeding 20 lb. useful work, representing a continuous power of 200, is very satisfactory. The class of engine, viz., a single vertical, is not equal in the writer's opinion to the usual Lancashire engines, horizontal and working in pairs. But why not take the better parts of each class, and have the usual Lancashire winding engine with a condensing arrangement attached? A condensing engine always ensures an effective pressure from the same steam of 15 lb. in excess of anything attainable from a non-condensing engine. The ordinary winding engine in the Lancashire district, taking steam from the boilers at 45 lb. above the atmosphere, equal to 60 lb. absolute, will do exceedingly well if it receives an effective pressure upon the piston of 30 lb., being one half used and one half lost. A condensing winding engine taking steam from the boilers at 20 lb. above the atmosphere, equal to 35 lb. absolute, will obtain an effective pressure upon the piston, inclusive of vacuum, of 27½ lb. So that with non-condensing engines the effective fraction would be about half, and with condensing engines three-quarters. At Bestwood Collieries, near Nottingham, there is a pair of vertical winding engines, 36-in. cylinders, which can be used either condensing or non-condensing. The steam pressure at the boilers is 60 lb., and the average vacuum obtained is 12½ lb. The air-pump of this condensing arrangement is worked by a separate engine, and the opening or closing of a couple of valves sends the exhaust into the condenser or into the atmosphere, and puts the winding engines to work condensing or non-condensing as may be required. If winding engines work condensing in the North of England and at Nottingham, there seems no good reason why the principle should not be applied in Lancashire; and although the writer's experience has been exclusively with winding engines without condensers, he

hopes before many years to see condensing arrangements fairly tried in Lancashire, by having a condenser and air pump to save existing high pressure winding engine. The simple arrangement whereby in a few minutes condensing can be changed to non-condensing, and *vice versa*, ought to encourage some Lancashire coal proprietor to try it. Second, by improved appliances in connection with the winding drums. In the days of our forefathers, when mines were worked near the surface, winding was not an important matter, any engine or rope or drum would do. But with depths of 600 and 800 and 900 yards, and in the future even greater depths, it becomes quite a different matter. What we want is that the load upon the engines shall be as uniform as possible, and several methods have been tried with the view of accomplishing this desirable end. In the North of England counter balance chains are used, and for vertical drums and flat winding ropes do well enough. The spiral drum, of which we have some examples in this district, is constructed so that the load multiplied by the diameter of the lap is the same all through the winding. The cylindrical drum, with a tail rope or balance rope under both cages, answers the same purpose, if the sump is deep enough, and the shaft moderately free from horse trees, landings and pipes. The general practice is to let the balance rope work unguided in the sump, but the excessive freedom has proved troublesome. Mr. C. F. Clark, of the Garswood Coal and Iron Company has had the balance rope working in this manner, but has had occasion during the last few months to make an alteration which the writer thinks an improvement. A pulley is placed in the sump, and under ordinary circumstances the pulley round which the balance rope works is stationary. But as the pulley is arranged to slide up or down between a framework, a two-fold advantage is derived. The balance rope always works

steady and keeps its position, and has no tendency to form the loop so usual with this arrangement, and should one cage be drawn too high without the other cage descending, the pulley rises freely and smoothly, and in all circumstances keeps the balance rope tight. Mr. Clark, who kindly placed particulars of this arrangement at the disposal of the writer, has within the past two days made a communication to the effect that "our tail or balance rope works admirably. We have not had the slightest hitch since it was put on." But all these drum appliances only partially meet the difficulty. The Kœpe system goes into the matter thoroughly, and dispenses with drums altogether. The principle of the Kœpe system is that no drums are needed, and, instead, a pulley is placed upon the crank shaft. The main winding rope, for there are several, has a cage at each end, and merely passes half round this drum pulley. Under the cages there is the ordinary balance rope just described, and there are two additional or safety ropes about half the strength of the main winding rope. These safety ropes pass over two pulleys placed in the headgear, and take hold of both cages. These safety ropes have nothing to do but move about so long as the main winding rope keeps right, and there is less danger of anything happening to the winding rope in the Kœpe system than with ordinary winding appliances. But nervous spirits seeing that only one main winding rope is used, and that in the event of this giving way, the whole affair would go down the pit, it was thought an improvement to attach these two light safety ropes. If the main rope breaks, these safety ropes come into operation, and both cages remain suspended safely. Sometimes there are no conductors, the idea being that the movement in winding is so steady that none are needed. The advantages claimed for the Kœpe system are:—(1.) Drums are dispensed with, and a simple pulley substituted. The expense of drums is saved,

and the weight, which is something enormous in large winding engines, avoided. The engines are brought closer together, thus lessening the length and diameter of the crank shaft, and the winding-engine house does not need to be nearly so wide. (2.) The load upon the engines is reduced to a minimum and made absolutely good throughout the winding. By this means a smaller pair of engines will accomplish the work. (3.) The pulley upon the crank shaft can be made exactly equal in diameter to the headgear pulleys, and the main winding rope is thus always coiling upon the same seize. (4.) The main winding rope is always working in the same line, and there is no side movement with its injurious influence. (5.) Only one main winding rope is needed, the balance rope being one which has done its work as a winding rope; the safety ropes are light, and have not much to do. (6.) The whole of the winding rope can be readily got at for thorough inspection, and no part of the rope is wearing itself away by injurious grinding influence upon other parts. Unfortunately the writer has never seen the Kœpe system at work, although he hopes to do so shortly, but believes that in its leading principles it is correct. It seems unwise not to have conductors in all cases, and, perhaps, the main winding rope, instead of only passing half round the drum pulley should be made to pass at least once round. But, in its abolition of massive winding drums, it is clearly a step in the right direction, and it does seem to give a less and more uniform load upon the engines than any other arrangement. At several places on the Continent the system has been working well for years, and has lately been introduced into England and applied at the collieries of the Bestwood Coal and Iron Company. Messrs. Nasmyth, Wilson, and Company, of the Bridgewater Foundry, Patricroft, near Manchester, write on

the 4th of January, that "the Kœpe system is being successfully worked at Bestwood, and we have orders for similar plant at a large colliery in South Wales." It seems to the writer of this paper, that by combining, without injurious complication, the benefits derived from the condensing arrangements of the North of England and the advantages derivable from the Kœpe system, we should be in possession of an almost perfect winding appliance. However that may be, no harm can have been done in introducing the subject to the Manchester Geological Society, many of whose members are colliery proprietors and mining engineers. In conclusion, the writer wishes to express his acknowledgments to Messrs. Nasmyth, Wilson and Company, of the Bridgewater Foundry, Patricroft, for the use of their very excellent diagrams. Mr. John Lancaster had most kindly undertaken to show the writer the Kœpe arrangement in full operation at Bestwood, but unfortunately Mr. Lancaster's health had compelled him to leave England. An opportunity, however, will be availed of for thoroughly seeing what the Kœpe system of colliery winding is capable of, and at some future meeting of the Society the writer hopes to bring forward some remarks supplementary to this paper. The system was the invention of Mr. Kœpe, chief mining engineer to Herr Krupp, the German steelmaker. When first introduced, the inspectors of mines objected to it for raising and lowering men, but after personal inspection this objection was withdrawn. With regard to its operation in England, there had been some difficulties. If a quick start was made the rope slipped upon the drum, and this was specially the case after greasing the rope; capping a rope was a serious undertaking, and changing a rope occupied a considerably longer time than with the old arrangement. Winding ropes, however, should neither need changing nor applying very frequently.

Mr. WINSTANLEY asked for information with regard to the working of the balance rope. He said that at the Monkton Main Colliery, in Yorkshire, where they used the balance rope; as also at Bestwood and elsewhere, great difficulty was experienced at first in getting it to work. This arose from its twisting and coiling in the sump hole. He believed the rope had to be made in a peculiar manner, and should be glad of any information that Mr. Percy could give concerning it.

Mr. E. PILKINGTON said it was claimed, as one of the advantages of the Kœpe system, that it lengthened the life of a rope. He found, however, that the rope always wore quickest at the cap, and that they had continually to recap the ropes,—an operation, which under the Kœpe system, would be impossible.

Mr. H. A. WOODWARD desired to know, in the event of an accident from over winding, or any cause which resulted in the loss of a cage, how would they act? Also, in the slipping of the rope upon the drum, what would become of the indicator?

Mr. JOSEPH DICKINSON, H.M. Inspector of Mines, said that he was using no mere empty phrase when he stated that, so far as any new arrangements connected with the working of collieries were concerned, he had found Lancashire always moving in the front rank. It would, however, seem that Nottingham had stolen a march upon them on this occasion in the introduction of something new. Whether it was from the general winding arrangements of Lancashire being always in a very complete state or whether it had arisen from a doubt as to the advantage to be derived from the adoption of a counterpoise to the rope in the shaft, it was nevertheless the fact that in Lancashire we had very few engines balanced. We had various descriptions of drums, but there were scarcely any engines in that part of Lancashire where they had the ordinary balance, as used in

the North of England. At the Pendleton collieries, a few years ago, there was one, but it had been removed. In the North of England these balances were used to a considerable extent, but in Lancashire there was no attempt to counterbalance the engines. It seemed that at the Bestwood Collieries there was not only a counterbalance, but there was a new system of winding without the ordinary winding drum. So far as their discussion went he thought they might look upon these as too separate systems not necessarily connected with each other, and what he wished to deal with specially was not the new system of winding, but rather the advantage or otherwise of having a rope in the shaft balanced. For the last half-century it had been the common system of winding in South Wales. There were a number of collieries there that had balance chains underneath and attached to the bottom of the cages. The rope was a new idea, and he thought had many objections which did not apply to the old-fashioned balance-chain. He thought great results might be expected from balancing the engines in this manner. In some remarks which had been made in different newspapers in connection with these balance-chains, it had been set forth that they could put on any old chain for the purpose. From long experience, however, he found that these balance-chains were just as liable to break as the rope which carried the load, and they should therefore be constructed of equally good material.

Mr. Aitken asked whether in the event of a balance-chain breaking with the cage near the top of the shaft the result would not be a losing of the control of the engine and an inevitable accident.

Mr. Dickinson: If such an accident as this takes place there is a general breakdown.

Mr. Aitken: Then the balance-chain introduces one more element of danger.

Mr. DICKINSON: Exactly so, and that is, perhaps, the reason why we have so few balance-chains in this part of the country. I may add that if the balance were double, and connected together, either as the ordinary double linked chain, or at short distances apart, such a contingency might be almost if not entirely avoided.

Mr. MARTIN, H.M. Inspector of Mines, said that eighteen months ago, when the members of this Society were at Bestwood, the balance-rope seemed to work evenly, and there was no lashing about in the shaft.

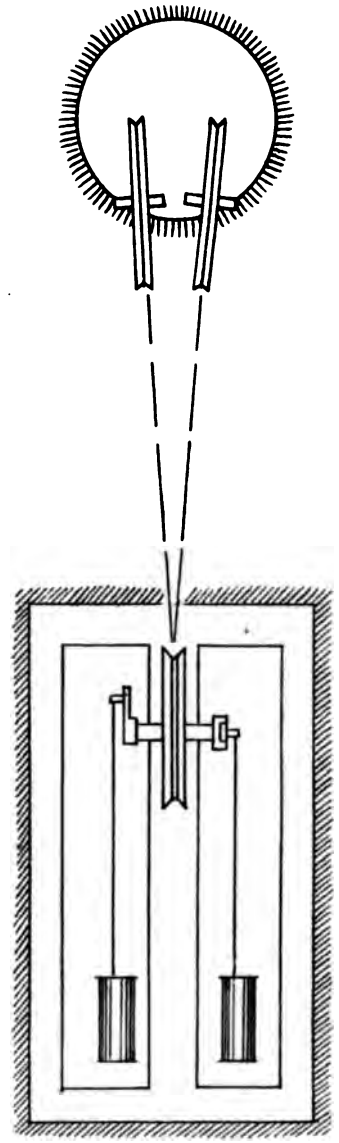
Mr. WOODWARD: Quite so; but they told us they had had trouble with it at the Pit.

Mr. PERCY, in replying upon the discussion, said he was at a disadvantage in not having seen the Kœpe system at work. He intended doing so, and would return to the subject at a future meeting. He was not responsible for defects in the system. He had been asked to prepare a paper, and had done so. His contention was that the Kœpe system was right in principle, and the defects were merely in matters of detail. It had been stated that the winding rope slipped upon the drum pulley, and this was true, but improvements could be and would be made which would prevent slipping. It had also been urged that if the main winding rope broke both cages would go to the bottom, and the safety ropes would not prevent the loaded cage running to the bottom. Winding ropes need not break in any case, and were less likely to do so with the Kœpe arrangement than any other; and as to the safety ropes, whilst he did not agree that they were necessary at all, it would not be difficult to arrange that running back should not result when the main winding rope broke. But his best argument was that these additional ropes were not needed. It had been said that ropes went first at the capping, and the Kœpe system made no provision for this. Ropes need

not go at the capping, and a good capping, under ordinary circumstances, would last as long as the rope. At the Bridgewater Collieries no catches were ever placed under the cages, and as a consequence the weight was never taken off the capping, the rope and capping lasted longer, and much time was saved. Mr. Dickinson, in speaking of the balance rope under cages, said he held that these balance ropes should be not discarded winding ropes, but should be well and specially made for the purpose. The writer quite agreed that for pits 600 and 700 yards deep there was a good deal to be said in favour of this argument, because the weight of the rope itself was considerable. But for pits not more than 300 or 400 yards deep he was of opinion that a winding rope that had done its work of winding might very well be put on as a balance rope. As to the pulley in the sump for the balance rope to work round, he only knew of its application at the collieries of the Garswood Coal and Iron Company. He did not go so far as to say that such pulley was absolutely necessary, but he did say that it was an improvement, and would recommend it.

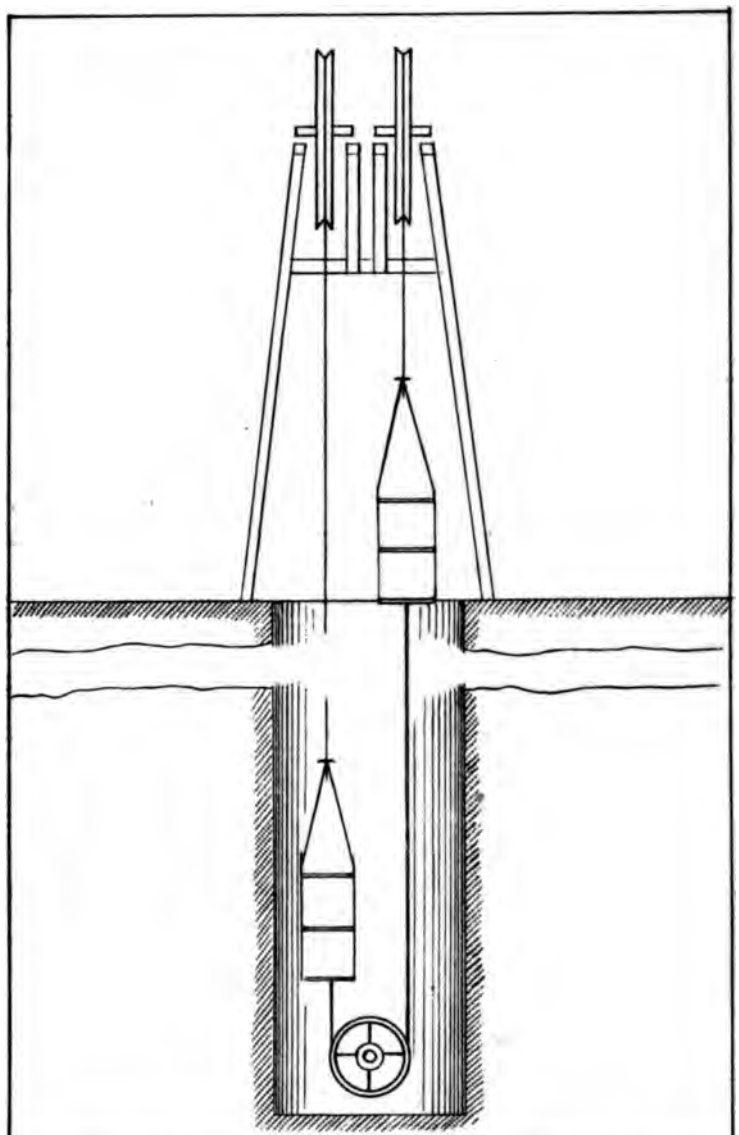
The President said he thought the subject had scarcely yet been exhausted, and it might be well to resume the discussion at a future meeting, when some of them might have had an opportunity of seeing the system at work. He pointed out that the idea involved in the Kœpe system was not new, for at a colliery, in the occupation of Mr. Lancaster and others, near Bishop Auckland, between the years 1839 and 1842, they had an arrangement very similar to that described. The pit, it was true, was but 40 yards deep, but the system which was found to work satisfactorily there, when applied to a deeper colliery was not a success, and had to be abandoned.

TO ILLUSTRATE C. M. PERCY'S PAPER.



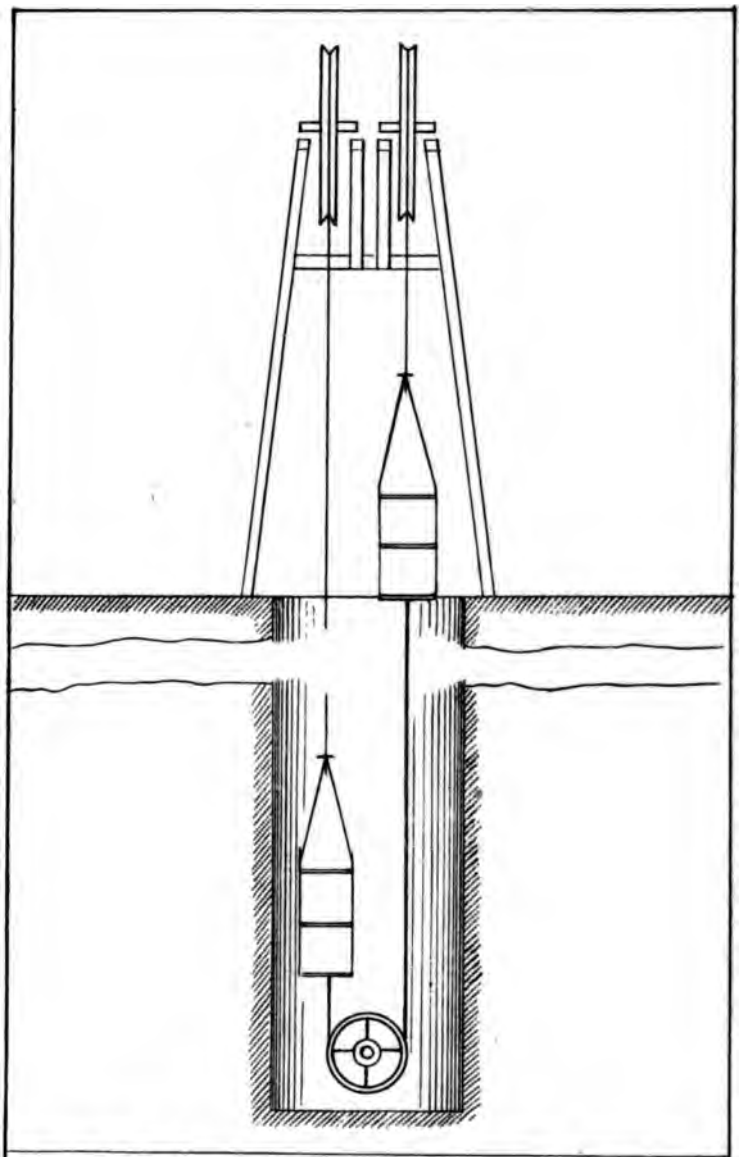
KŒPE —— PLAN.

TO ILLUSTRATE C M. PERCY'S PAPER.



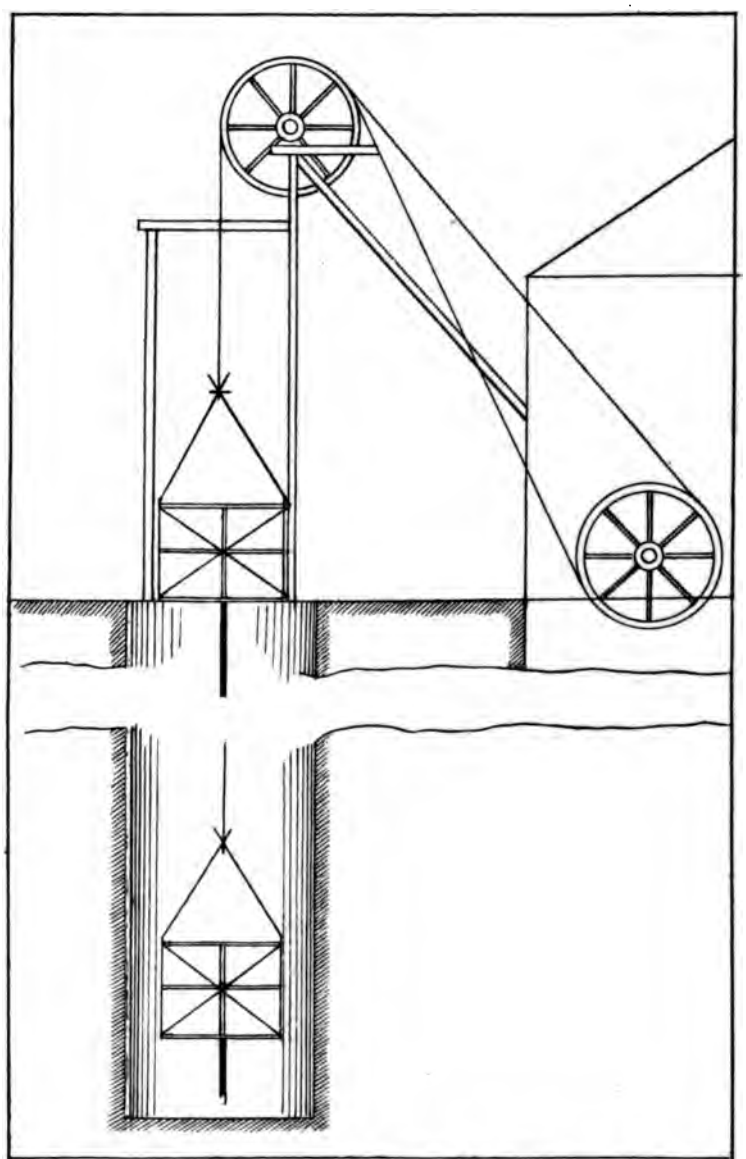
KŒPE — FRONT ELEVATION.

TO ILLUSTRATE C M. PERCY'S PAPER.



KŒPE — FRONT ELEVATION.

TO ILLUSTRATE C. M. PERCY'S PAPER.



KŒPE —— SIDE ELEVATION.

ON THE DISCOVERY OF FLINT IMPLEMENTS ON THE HIGH HILLS IN THE NEIGHBOURHOOD OF ROCHDALE.

By Messrs. Robert Law and James Horsfall.

A series of investigations into the distribution and mode of occurrence of Neolithic flints was commenced by the writers of this paper in the Spring of 1879. The work had been carried on more or less successfully for a period of two years. The places visited were the highest summits and most prominent hills in those parts of the Pennine Range which lie within a radius of about twelve miles of Rochdale. The first point was Dean Clough, a small upland stream about a mile north-east of a place called Junction-in-Saddleworth, where no fewer than 150 flints were found. These consisted of chippings, flakes, one or two small cores, and in one instance a beautifully-worked arrow-tip of the barb pattern. In subsequent visits to this locality other flints had been found, one of the most interesting being an elegantly-fashioned and delicately-chipped leaf-shaped arrow-head. Flints appeared to be so abundantly scattered on this elevated moorland that in nearly every case, where an opportunity was offered for an examination of the subsoil one or more of them could be always found. The most striking example was met with on March Hill, a conical eminence overlooking the vale of Marsden. This hill is completely isolated from the surrounding moors, and although of comparatively small dimensions more than 1,000 flints were discovered on a few small patches of bare ground on its southern side. The number of small chips and flakes were so great at this place as to lead to the conclusion that flint implements were manufactured there during pre-

historic times. On the side facing the north, although there was bare ground, not more than ten pieces were picked up. During the Summer of 1880 the place was re-visited, and other flints were found there. About two miles east of this part stands Pule Hill, the most striking and prominent eminence in the neighbourhood, which proved to contain flints, though not in large quantities. Near the foot of the hill patches of subsoil were examined, and yielded upwards of 200 fragments of flint and chert, comprising chips and cores. While examining this part of the Pennine Range a sharp look-out was kept for other stones foreign to the district, but not a fragment was met with. Attention was next turned to an elevated and prominent ridge of moorland which lies about four miles west of Rochdale and then proceeds north-west towards the neighbourhood of Burnley. On several parts of this ridge flints had been picked up, the most interesting discovery being made on Middle Hill, near Whitworth. At one end, facing the south, flakes and small cores and worked fragments were so abundantly scattered over the bare ground that not less than 350 had been picked up. It might not be out of place to call attention to one or two points in relation to the flints discovered. The well-formed barbed arrow-heads and other well-worked flints were so associated with those showing little or no design, such as chips and flakes, as to leave no doubt in the minds of the discoverers that they all had a common origin, and must have been fabricated by pre-historic man. In all cases the flints, flakes, and cores were of comparatively small size, which might be accounted for on the supposition that this material was a scarce commodity among the ancient tribes who inhabited these hilly districts. This would seem all the more probable if we take into consideration the only two possible sources from which the flints could have been derived, viz., the glacial drift and the

far-off chalk districts. So far as their investigations had gone, they had failed to detect any trace of polished stone celts, and in only two doubtful instances had grinding or polishing of the flints been observed. Had these ancient Britons been in the habit of using polished stone hatchets, it was not unreasonable to suppose that some of the fragments of them would have been left behind, especially at places where implements appeared to have been manufactured. It had been pointed out that on two hills flints had been found more abundantly on the southern than on the northern slopes, and this was true of almost all the elevated places where they had yet been able to detect flints. This might be explained by the supposition that ancient men selected the more sunny and warmer side of a hill for pitching their tents and carrying on the work of fashioning their tools and weapons.

Mr. Aitken said he had been much pleased to hear the paper read. He was, himself, one of the earliest investigators in the district referred to, and in 1874 he read a paper before the Society in which mention was made of his discovery of two flint flakes on Bull Hill, and others in other places mentioned by Messrs. Law and Horsfall. At a subsequent meeting he announced that he had further discovered a considerable number of flints on Bull Hill, and among the rest the two arrow-tips which he now exhibited, together with many scores of flakes, and one core. At one place the flint chips were so numerous that he was led to believe that flint implements had been manufactured at that particular place. The occurrence of flint flakes in such situations was not uncommon. It had been shown, by the paper just read, that they occurred on almost every eminence of the Pennine chain. Mr. Law

had mentioned all the most prominent points in the district of which Rochdale forms the centre, and many of those places he (Mr. Aitken) had himself visited long ago, and had found flints there. On the Yorkshire moors they seemed to abound as much as on the western slope of the Pennine chain. Some time ago he visited Allendale in Northumberland, and there on a patch of ground denuded of vegetation by the fumes from adjacent lead works, there were thousands of flint flakes and implements. He visited the ground, in company with a gentleman who had previously been there and collected a large number of specimens, among the rest are some beautiful arrow tips and a polished stone celt, and, like one of the flint chips mentioned by Mr. Law, it was in two pieces, the pieces lying some little distance apart. Flint implements had also been discovered on the Derbyshire Moors and his opinion was that they existed in large numbers on every prominent hill in the range from Derbyshire to Northumberland.

Mr. PLANT said he could fully corroborate all that had been stated relative to the abundance of flint chips, over the Lancashire and Derbyshire moors. He had himself found them in the neighbourhood of Castleton, and near Burnley. They seemed to occur under about the same conditions as those so well described by the reader of the paper. With regard to the age of the flints, however, he must differ from much that they had heard. Most of them he believed were nothing more than the ordinary "strike-o-lights" and old gun flints, in common use before the invention of lucifer matches and percussion caps. It was well-known that the moors had always, from the times of the Britons and Anglo-Saxons—who used arrows—been hunting grounds for wild birds and animals, and the fact of broken flint arrow tips being found

there now, might be accounted for by their being thrown away or lost in the chase. Among the specimens of flints exhibited he saw no such thing as a prehistoric weapon of defence except those arrow tips; the rest were mere waste fragments of recent age.

Mr. M. STIRRUP said that Mr. Aitken, in his remarks, carefully avoided hazarding any opinion relative to the age of these flint weapons. He (Mr. Stirrup) could not help being struck by their modern appearance, and was inclined to agree with Mr. Plant that they could not be taken—at least the great majority of them—as belonging to what Mr. Law had called pre-historic man. They differed from the genuine flints of pre-historic times. The latter always had a weathered appearance, which was totally absent from Mr. Law's specimens. Indeed these specimens, so fresh and new-looking were they, might have been chipped only a few weeks or months ago. As showing how common was the use of flint weapons among savage tribes, he exhibited specimens of worked arrow-heads from the United States. They had been used by the Indians in the pursuit of their game down to very recent times, and he was told that they might be picked up in hundreds in some of the American river-valleys—in Illinois, Indiana, and elsewhere.

Mr. AITKEN said he did not know whether he understood Mr. Plant to say that all these remains were of Saxon and British age, or whether a portion of them were so.

Mr. PLANT: Only the arrow-heads.

Mr. AITKEN said that if Mr. Plant meant to suggest that they were of such modern origin he must certainly differ from him on this ground: when Julius Cæsar came to England he found steel and iron in general use among the inhabitants, and these metals being so much better adapted for purposes of the chase or war, as well as all domestic uses than flint, they could

not conceive it possible that the use of flint would be resorted to very extensively at any future period. It was reasonable to suppose that those flint implements must be of older date than was assigned to them by Mr. Plant from the position in which they were found. Flint in the neighbourhood of Rochdale was extremely scarce. The result of 15 or 20 years' search had been to find only some eight or ten pieces. With regard to the so-called "strike-o-lights," it seemed a very improbable place to look for them, on the top of a hill. He knew that these "strike-o-lights" were not uncommon, but it was not to be supposed that people in recent times would sit on the top of the Lancashire hills, 1200 or 1400 feet above the sea, to smoke their pipes, and throw their tools away immediately after they had used them. They would be too valuable to be used in that way. Moreover, the abundance of the chips showed that they must have been extensively used in the places where they were found. He admitted that flint, or some other hard material, must have been used alongside with steel to some extent down to the period mentioned by Mr. Plant, but he was not aware that it had ever been shown that stone implements were used in the Saxon period. They might have survived in some out of the way district, but more as curiosities than for general use.

Mr. Plant said he did not see upon the table a single flint which had upon it the skin characteristic of ancient flint implements.

Mr. Dickinson said he recollected, when flint implements were first brought under the notice of the Society, that he was sceptical as to their ancient character: he was not prepared to run the full length that scientific men were then running. He was glad to find, now, Mr. Plant expressing much more ably the views he Mr. Dickinson then held.

The PRESIDENT in closing the discussion said that whatever differences of opinion might exist as to the age of the flints, they were not the less obliged to Messrs. Law and Horsfall for their excellent papers and for the trouble which they had taken in collecting that large number of specimens. The subject was a very interesting one, and probably they would feel impelled to continue their investigations.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XIV. VOL. XVI. SESSION 1881-82.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 7th day of March, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOSEPH DICKINSON, Esq., F.G.S., Vice-President, in the Chair.

NEW MEMBERS.

The following gentlemen were proposed, balloted for, and duly elected ordinary members of the Society:—

JOHN DAVENPORT, Chamber Collieries, Oldham;

B. B. GLOVER, Haydock, near St. Helens.

The following are the recent additions to the Library:—

The American Institute of Mining Engineers: Transactions, Vol. IX.—*From the Institute.* The Dundee Free Library: Report, 1881. The Geological Magazine, Nos. 212-213.—*Purchased.* The Geological Society, London: Quarterly Journal, No. 149.—*From the Society.* Institution of Mechanical Engineers: Proceedings, No. 4 (October, 1881.)—*From the Institute.* The Midland Institute of Engineers: Transactions, Vol. VII., Part 56. — *From the Council.* The Mining Institute of Scotland: Transactions, Vol. III., Parts 10-11.—*From the Council.* Museum of Comparative Zoölogy. Cambridge, U.S.A.: Bulletin, No. 12, Vol. VI.;

Nos. 1 to 5, Vol. IX.—*From Alexander Agassiz.* The North Staffordshire Institute of Engineers: Transactions, Vol. II., Parts 4-5; Vol. IV.; Vol. V., Parts 1-2; Vol. VI.—*From the Council.* The Royal Dublin Society: Scientific Proceedings, Part 7, Vol. II. (N.S.); Parts 1 to 4, Vol. III. (N.S.); Scientific Transactions, Parts 13-14, Vol. I. (N.S.)—*From the Society.* The Royal Physical Society, Edinburgh: Proceedings, Session 1880-81.—*From the Society.* The Royal Society: Proceedings, Nos. 217-218, Vol. XXXIII.—*From the Society.* Victoria: Reports of the Mining Surveyors and Registrars, Quarter ending 30th September, 1881.—*From the Royal Society, N.S.W.* Der Kaiserlichen Leopoldinisch, Carolinischen Deutschen Akademie der Natur: Odd Numbers of Transactions. Der Deutschen Geologischen Gesellschaft: Zeitschrift, Band XXXIII., Heft 3, 1881.—*From the Society.* L'Académie Imperial des Sciences de St. Petersbourg: Mémoires, VII° Serie, Nos. 1 to 4, Tome XXVI.; and No. 2, Tome XXIX.; Bulletin, Nos. 1-2, Tome XXV.—*From the Academy.* Societá Toscana di Scienze Naturali: Processi Verbali, Vol. III.—*From the Society.* Société Géologique du Nord: Annales VIII., 1880-81.—*From the Society.* R. Accadamica dei Lincei: Transuntis, Vol. VI., Fas. 3-7°.—*From the Academy.*

THE LONG-WALL SYSTEM OF WORKING COAL AT WESTLEIGH.

The discussion on Mr. Hilton's paper, read before the Society on 6th January, was resumed. (See Part xii., Vol. XVI.)

Mr. Hilton, in reply to the Chairman, said that he had nothing to add to the paper; he had simply stated the facts with regard to the working of the Westleigh Mine, and if any gentleman desired further information, he should be glad to supply it.

Mr. C. F. Clark asked whether the Hindley 4ft. overlying the 6ft. had been worked.

Mr. Hilton replied it had not.

Mr. Clark said that the reason why he did not work long-wall at their pits was because he was afraid of making too much dirt.

Mr. WOODWARD: There is one thing which is not quite clear to my mind, although I have been down this mine and have seen the workings. The paper, I think, says that they work at "the end of coal," but according to the plan here shown, and the direction of the inclination of the mine, I cannot quite see how they can be working at "end of coal." It seems to me, from the direction of the drawing roads, that they are working half end and half face, and pretty nearly in the line of cleavage of the coal. If I am mistaken, I should like to have it explained. I would also like to ask a question with regard to the cost. I cannot quite see how the cost of timber should be reduced from 3d. to ½d. per ton; it seems to me a very large reduction.

The CHAIRMAN: If Mr. Woodward will be good enough to look at the place again, and observe the north point, he will see that the ruled lines do not really represent the cleavage of the coal. I think most of us know that the cleavage runs in a N.W. direction; this is shown as running N.E.

Mr. J. S. MARTIN, (Hon. Sec.): The shading, in the plan, has been merely put on by the draughtsman instead of colour; it has nothing to do with the cleavage.

Mr. WOODWARD: My difficulty is this: it appears to me the levels are driven upon the true end of coal, and that the working face is not going upon the end of coal, but is half end and half face. That is the thing I look at; but of course, according to the dip of the mine, the cleavages would run half way across that north point.

The CHAIRMAN: I think I can explain that. I believe long-wall work was first commenced at the right hand side, and that it was driven towards the right almost upon the face of the coal; but, going up-hill, the workings will be pretty nearly on the end—about half end and half face.

Mr. WOODWARD: I can quite understand that on the

right hand side the working has gone on the end of coal, but not the face as now advancing.

Mr. HILTON: The coal is not exactly on the end, but it is almost on the end—the levels are on the face of coal. It is as near on the end as we can get it. As to the cost of timber, it is, as I have stated, ½d. per ton. The reduction, I suppose, is owing to the roof requiring less timber, being supported by the packing behind. In fact, it works out less than ½d., taking a quantity at once.

Mr. MARTIN: A good deal has been said and written recently with regard to the use of powder in mines, and I think the Trencherbone, on Wigan 9ft. Mine, is one of those which has been referred to in some reports as requiring exceedingly heavy charges, about 2lbs. or more of powder. I should like to ask Mr. Hilton, inasmuch as in this colliery powder is not now used at all, whether he can give any account of the relative cost of working it with and without powder. Then, when a fall has taken place, can the hollows be kept clear of gas behind where the men are working, and what means are taken to remove gas in the event of its accumulating? With regard to the cost of timber, I assume it is not the cost throughout the mine, but at the face only, which is referred to.

Mr. HILTON: That is so. The timber used for propping.

Mr. MARTIN: This question with reference to gas lodging in cavities, sometimes not more than two feet high, where powder is allowed to be used at all, is one of considerable importance, and necessitates care. That is my reason for asking the question.

Mr. HILTON: There has been no comparison made of the cost of working with and without powder at Westleigh.

Mr. MARTIN: Can you speak of it in the same mine, whether at Westleigh or elsewhere, in comparison with pillar and stall, where powder is considered necessary?

Mr. HILTON: I have tried to get at it, but have not been able to satisfy myself sufficiently to give an answer that I should like printed. We can scarcely get at it, unless it is tried in the same mine and exactly under the same conditions. (Hear, hear.) Then, as to falls in the goaf. Occasionally we have falls before we can get it properly packed, and at once gas is seen in the cavities, but this is removed as quickly as possible by placing brattice cloth in order to force a current into the cavity.

Mr. J. S. BURROWS said that with regard to the 5-ft., or Trencherbone mine, if there was such a roof as they had in the adjoining colliery, he did not think it could possibly be worked by pillar and stall. Powder was not used lest there should be gas in the cavities behind the men. When once a start was made—and it was always with considerable difficulty—they could get the coal without powder. He should say, as a rule, taking the coal to be of the ordinary hardness, he did not think if they began without powder the cost would be very much greater than if powder were used. The difference would be practically nothing.

Mr. MARTIN: My reason for asking is because I have seen it stated in the *Colliery Guardian* that to do away with powder would increase the cost of working from 6d. to 2s. 6d. per ton, or some apparently excessive figure.

Mr. HILTON: I have no doubt that, in some cases, what is said by the *Colliery Guardian* is quite true. I have no doubt it would cost 7d. or 8d. per ton more to work it without powder by the pillar and stall.

Mr. MARTIN: Working long-wall in those mines—can they be worked advantageously without powder?

Mr. HILTON: They have tried the long-wall system and it proved a failure: they had not sufficient packing stuff, and having a hard floor and roof it became unmanageable, and they had to resort to pillar and stall.

Mr. MARTIN: I asked with reference to working the seam whether, if wide work were introduced, and the principle carried out thoroughly and well, it would increase the cost.

Mr. HILTON: If it could be introduced I do not think it would cost any more.

Mr. BURROWS: I was speaking of wide work when I said that it would probably not cost more. There is one other matter about the use of powder for wide work—following up Mr. Martin's question about cavities. You cannot always clear them with brattice cloth. I have purposely explored them in order to get at the source of the mischief, and have very often found the gas issuing out of a break in the roof. It rises from the workings below, no doubt, and no amount of brattice will remove it entirely.

Mr. WALLWORK: We have not worked much at our collieries without powder, but I think every practical man will say that in some mines the disuse of powder would add a little to the cost of getting the coal. According to my experience—and it is a pretty long one—a good deal less powder might be used; especially where long work is introduced and could be maintained.

In reply to the Chairman, Mr. WALLWORK said that he had driven a good many more narrow levels than wide ones. In future, wherever he had to open out, he should try more than he had yet done the opening of wide places, and packing both sides. He had already done this in some places, and it seemed to answer pretty well. He did not, however, advocate the beginning a pit and getting coal, wherever they drove, either narrow or long work; he should rather get to the far end and work back. He should bring it back in long work.

Mr. TOPPING: We are working the same seam, but not long wall. Having seen the work at the Wigan Coal and Iron Company's Collieries, however, I am convinced that it

is the correct method, where it can be fully carried out. It may also be the least expensive, but it is certainly the safest. But it is not to be supposed that because the 6ft. is got at Westleigh by long-wall, therefore all mines in the 6ft. in the Wigan district can be so worked. My experience is directly opposed to that. I have come to the conclusion that, in our individual case, the coal could not be worked to greater advantage than it is, by any other system. The method adopted at Westleigh, whilst it may be a guide to some, cannot dictate to all, or be taken as a hard and fast line for all to follow. Our 6ft. mine, which is considerably harder than the Westleigh seam, is worked with powder, and we find that, in the narrow places, every fourth wagon is one of slack. There is about 75 per cent. of coal, and 25 per cent. of slack. The width of a place is never more than 9ft. That is in straight work; but where we drive a 4 yd. place without powder, we get a very much larger per centage of coal than if the places were much narrower. It would be a very serious thing if we were to attempt to open out the 6 ft. coal long-wall, and it would jeopardise the other mines above, or bring about what the landlord might term a breach of covenants.

Mr. Dodd: The figures in the paper represent the cost of getting as exceedingly low: 1s. 6½d. and 8d.—that is, in all 2s. 2½d. But that, I presume, scarcely brings the coal to the pit shaft. It does not raise it. It means, I suppose, 2s. 2½d. at the shunt: the distance, therefore, between the shunt and the pit shaft has to be estimated. Then there is the cost of raising it and putting it into screens; and putting together all these incidental expenses, there will not be found any real substantial gain. The whole question is one of safety; that I admit.

Mr. Merfyn said that where the long-wall system was properly worked, there should be no necessity for timbering.

He was much in favour of pillar and stall. In Yorkshire they had to do away with powder in some of their mines, and the extra cost was about 2½d. per ton.

In answer to the Chairman, Mr. MERFYN said the seam would be about 7ft. or 7ft. 6in.

Mr. RADCLIFFE said that he had seen the long-wall system at Westleigh, and it impressed him as being about the best he had seen. He is just now starting the Roger mine at Dukinfield on the same principle.

Mr. S. B. GILROY suggested the expediency of tapping the underlying seam, so as to draw off any accumulated gas.

The CHAIRMAN: I think Mr. S. B. Gilroy has named a very important matter with regard to the working of this coal—that is, letting off the gas from the seam which lies 40ft. below the main bed that is being worked. As soon as this shaft was sunk, it being in my district, I asked Mr. Martin to go over and see if it was making much gas, as I expected a large quantity coming off, every other pit in the Wigan district, except Mr. Topping's, having fired. Mr. Martin visited the pit, and reported to me that it was making a very large quantity of fire-damp, but that he found every precaution being taken which appeared to be reasonable. Hearing of this large quantity of gas, I went over to see for myself, and went round the pit with Mr. Jackson, Mr. Hayes, and some others. We found gas in large quantity being given off, as is common in this seam. In talking the matter over with Mr. Jackson, we agreed that it would be desirable to put a bore-hole down to the coal which lies 40 feet below, and see what gas it would then give off. The result was that the gas when first tapped came off at a pressure of 30 lb. on the square inch. The egress of this gas was found to be a source of some inconvenience and danger in the mine; but this was got over by putting an iron pipe into it furnished with a stop cock, and

having this stop cock closed when the men were at work and open only when they were out of the mine. In this way the gas was let off until the pressure was reduced to about 15lb. on the square inch ; and I think at that pressure they have found gas in all the succeeding holes they have put down. Had these bore holes not been put down, it is not improbable the slightest mistake would have brought about the same results as have been experienced in so many other mines in this seam. It has not only had the effect of letting off the gas and getting rid of it, but also of reducing the pressure very considerably, and it is one of the items by which the cost of timber has been so considerably reduced. It has taken the pressure off, so that they have now nothing to deal with but the pressure of the superincumbent strata. The gas, as tested in the North of England, attains 700 lb. pressure on the square inch. In this case the pressure they are getting is only about equal to the actual weight of the strata, between the seam which they are working at and the depth to which they have bored. You will see these bore-holes marked on the plan. After finding successful results from one, and after some months' use of this they sank other two near the face, and now they have six or eight, as shown on the plan. The colliery at the time these sinkings were made was on narrow work, and the workings had to be bratticed very closely up to the face, sending round the face a strong current of air. It was in consideration afterwards, I think, that they resolved upon resorting to long-wall ; and this has had the effect of letting off the gas so gradually that I am not aware any unusual difficulty has been experienced in the working of the mine, although it is emitting the large quantity of fire-damp which I have mentioned. Another point worth special notice in the working of the long-wall system is the very large quantity of dirt they make by holing. According to the section, they are holing

2ft. 7in. of dirt, and that dirt fills up the gobbings almost as tight as they can stow it, leaving no cavities for gas to lodge in, such as would occur were the workings only partially or scarcely filled at all, as does take place in some mines. I should like to ask Mr. Hilton whether they have yet put a bore-hole up to the seam above. It might be important to see whether the gas in it is existing under similar pressure and quantity as the others.

Mr. HILTON: The bore-hole has been started to the seam above, but it is not yet finished. It is some distance up, but has not tapped the coal yet.

Mr. TOPPING: There can be no doubt that the putting down of these bore-holes lessens the pressure considerably, and thus contributes to the decreased cost of timber necessary in the pit. But I should not like it to go forth that, because the holes have been put down to the lower seam, the gas from that seam has mainly contributed to the explosions of gas which have taken place in the Wigan 6ft. mine. As I said before, whilst it is prudent that these bore-holes should—and I think they might be put down, whether the work is narrow or long work, I believe the main pressure of gas has come out of the 6ft. mine itself. We have bored holes in the leading levels, and we find that in the softer coal the pressure is 40lbs., whilst in the harder—about 18 in. below the roof—where the bulk of the gas is given off, we get 65lbs. This pressure was given instantly, and it continued for fourteen days; and I have not the slightest doubt that, if we could bore a hole sufficiently advanced the pressure of gas in the 6ft. mine would reach 2000lbs. on the square inch.

The CHAIRMAN: I do not think the gas will be found in any instance to have a pressure greater than the superincumbent strata; and as yet we have not found it to exceed 600lbs. or 700lbs. on the square inch.

Mr. MARTIN: With reference to the objection Mr. Topping has raised to working by the long-wall system, when two or three seams are worked together, how would it apply if they worked it to the far end, as Mr. Wallwork has suggested? If the levels were driven 20 yards wide, to the further end, then work the two seams or three seams together—keeping the faces as nearly as possible equal—would the long-wall system be advantageous or disadvantageous?

Mr. TOPPING: Mr. Martin assumes a case, and the assumption is this—that the three mines can be worked long-wall. My position is—that our Wigan 4ft., with the 30 yards of rock roof resting upon it, cannot possibly be worked by long-wall to as great advantage as it is now worked; but if all the mines could be worked simultaneously on the system of long-wall, and were equally applicable to be so worked, then long-wall would be the correct thing. It is simply an assumption.

Mr. MARTIN: One is as much an assumption as the other—to say that it cannot be done if it has never been tried.

Mr. W. PICKARD, bore testimony, from his inspection of the mine, to the excellent results of the long-wall system at Westleigh.

SAFE LIGHTING OF COLLIERIES.

BY MR. W. E. TEALE.

Mr. TEALE said, that the lighting of collieries is eminently unsatisfactory, is generally acknowledged. It is important that steps should be taken to diminish this loss of life from explosions, and I trust that this paper will be the means of leading some of those who are responsible for the safe lighting of collieries, to carefully weigh the reasons which I

propose to advance, why it is possible to do so with safety, and also in other respects, it is to the advantage of all concerned, from the owners down to the smallest boy in the pit. The rapid development of coal mining during the last 20 years, the constantly improving machinery that is being used, the improvement in the methods of ventilation, the greater area and depth of mines now worked, the rapidity with which the coal is won, is truly surprising, and would tempt one to exclaim—"There are no difficulties that the mining engineer is not able to grapple with and overcome." But, although so much has been done and such rapid progress made, there is one portion of the surroundings connected with the working of collieries which, I venture to say, has had less light thrown upon it than any other matter connected with collieries, and that is, lighting with safety. Of all subjects it is the one that is most present to every one who descends the pit, and it is the only one that all who are occupied in collieries are obliged to have to do with. And, further, there is nothing concerning collieries in which there is a greater divergence of opinion. As a proof of this, it is only necessary to travel throughout the coal fields. Lamps of almost every conceivable shape and kind exist. Collieries will be found using naked lights, some with part open and closed; others use Davy, Clanny, Mueseler, Stevenson, or a combination of two or more kinds. The system adopted in their use and management is almost as varied. The reasons given for the different systems pursued are most curious. The only conclusion that one can come to—the first step to be taken towards an improvement in the lighting of collieries, is, to try and reduce the great mass of divergent opinions and lessen this anomaly. I am strongly of opinion that naked lights should be abolished, and that the safest description of lamp securely locked should be used. By the term safety lamp, I mean such a

lamp as will give security in a still atmosphere, or under a pressure of explosive gas, and that will effectually prevent the user of it from exposing the flame, give sufficient light, and which may be examined in all its fitting parts; above all, should be self-extinguishing when placed in an explosive atmosphere. The use of such a lamp would not prevent matches being taken down, or the wilful destruction of the lamp; but the utility of matches for the purpose of re-lighting the lamps might be made practically impossible, and the attempted wholesale destruction of his fellow-men and suicide of himself is a contingency that would be prevented by the extinction of the flame in an explosive atmosphere. The production of the Davy, Clanny, and Stevenson lamps was thought to provide a means of safely lighting collieries; but experience has proved, unfortunately, they are not to be relied upon. With regard to the Davy lamp in the hands of a competent man, it will be found in most circumstances a valuable means of detecting gas with little risk. Its disadvantages are—it cannot be relied upon if submitted to a current of explosive gas, at or exceeding 5 feet per second, and will, if allowed to continue burning in gas, cause the gauze to become heated sufficiently to ignite the surrounding atmosphere. In submitting this lamp to tests favourable to causing an ignition of gas—*i.e.*, the atmosphere shall be so composed as to give the best effect—it will be found that the gauze will become filled with a blue flame, and continues burning until the gauze arrives at a flame heat, and eventually fires the surrounding atmosphere. By causing the gas to pass through the lamp, or the lamp to travel through the gas at varying velocities, the ignition takes place the more rapidly it approaches the speed of 6 to 7 feet per second. No safety lamp can be so easily the means of causing an explosion as the Davy lamp, on account of the ease with which it frees itself from the results of

combustion—carbonic acid gas—the very current finding on one side the means of sustaining combustion, and on the other driving out the carbonic acid gas. The Clanny varies considerably as to its action under similar conditions. The glass or combustive chamber acts as a receiver for the carbonic acid gas, the gauze above being filled with blue flame; the heat produced causes the carbonic acid gas to circulate, and tends to lower the heating power of the flame, prolonging the time taken to ignite the surrounding atmosphere, and requiring an increased velocity of 2 to 3 feet per second more than the Davy to produce the same effect. The action of the Stevenson is very different to either of the two named. The combustion of the flame is maintained by small openings beneath the flame; these perforations are only of sufficient size and in number to support combustion under conditions that are favourable, viz., freedom from gas. When, however, the air is charged with gas, the carbonic acid gas produced by combustion has ordinarily not the power to pass out of the lamp, but falling by its own specific gravity, extinguishes the light. Should, however, the flame within the glass cylinder be prolonged sufficiently, and the velocity increased, the power of driving out the results of combustion, materially assisted by the increasing temperature, will be attained, and the ignition at a velocity of 10 to 12 feet per second will take place. An explosion of gas may take place in two ways, viz., the gauze becoming heated to a flame heat, or the temperature of the flame burning within the cylinder increasing to such an extent as to throw off the results of combustion and allow it to pass through the meshes of the gauze without the latter having the ability to reduce its temperature below the ignition point. I do not think it is possible for a visible flame to be passed through the meshes of a gauze 28 by 28 to the square inch, or a less sized mesh than will allow a certain amount of air to

surround and pass with it, so as to support combustion through so narrow a passage as the mesh of a gauze. It is necessary to investigate the action of the different lamps, and the results produced, in order that they may be so constructed as to give the best results under ordinary circumstances, and provide a remedy when submitted to more severe conditions. Besides the lamps named, the Mueseler or Belgium lamp may be described as an upcast within a downcast shaft, the chimney surrounded at its base with a circular piece of gauze fitting within the gauze cylinder, the wick tube being surrounded by the glass chamber, the oil vessel when screwed into position holding the glass tightly. The flame of the lamp under ordinary conditions is fed by the air passing in through the lower part of the gauze, the circular piece of gauze surrounding the chimney down the inside of the glass and to the lower part of the flame, the results of combustion passing through the chimney. The conical form of the latter will allow the passage of the carbonic acid and vapour produced by the combustion of the oil, but if the air with which the lamp is fed be charged with carburetted hydrogen, the form of the chimney prevents the increased quantity of carbonic acid gas from passing away freely; falling into the glass chamber more rapidly than the ventilation can contend against, the flame is forced from the wick to the underneath part of the gauze, and continues burning until the glass chamber is filled with carbonic acid gas, when, if the heat generated is not sufficient to overcome the resistance of the horizontal gauze and pass into the upper cylinder, the flame is extinguished. Submitted to tests similar to the three lamps first named, this construction of lamp gives much better results, going out much more rapidly and withstanding a much higher velocity of explosive gas. But under certain conditions this lamp will cause an ignition, and I attribute it to the base of the chimney being

lengthened below the gauze, which prevents the glass chamber from becoming perfectly filled with carbonic acid gas. The results of the Commission in Belgium caused them to recommend this lamp for adoption as the nearest approach to a safety lamp, although they were alive to the fact that under certain conditions it might become the means of an explosion, as the following extract will explain:—"The whole of the experiments have proved that no means of lighting can be as absolutely safe. So far as the Davy and the Pirion lamps are concerned, it has been shown from the beginning that they give no kind of security in an explosive current travelling 1·70 m. per second. The Commission has only used these lamps when it desired to produce explosions, and principally to assure itself of the compositions of the mixtures. The Mueseler lamp, typer or not type, has generally behaved well; nevertheless, it has in many cases produced explosions, of which the decided causes have not been known; the special manœuvre of the hydraulic valve, the greasing of the horizontal gauze, swinging, and the whirling ascending currents, have also produced explosions." With respect to the Belgium Mueseler lamp, it does not consist only in having a chimney surrounded by a gauze, but in having the chimney with a sufficiently small outlet, and that the gauze shall be accurately fitted. When turned on one side, so that the flame is out of the perpendicular of the chimney, the ventilation becomes reversed, and the action of the carbonic acid extinguishes the light. If the flame is allowed to become too large, so as to cause soot to be deposited, the flame is deteriorated, and does not give sufficient light. This gives rise to attempts on the part of the lampman to improve the lamp by cutting away a portion of the chimney, so that the diameter of the outlet is increased, in this condition; or, if the gauze is imperfectly fitted to the chimney, will, when the lamp is placed in explosive gas,

become filled with flame between the gauze and chimney. It then becomes far more dangerous than any other lamp. The diameter of the gauze allowing a larger body of flame to exist, and the chimney snrrounded by flame absorbs and retains the heat (which ought to pass away), until a flame temperature is obtained, and an ignition of the surrounding atmosphere ensues. I would here urge upon all who have or contemplate using any Mueseler lamps, to carefully watch these two points, viz., the area of the outlet of the chimney, and the perfect fitting of the horizontal gauze. The Davy, Clanny, and Stevenson were the lamps generally used up to the last few years, and the Mueseler was the system selected in but three or four instances. Many modifications have from time to time been introduced, but have failed to supplant those, with one or two unimportant exceptions. In the Mines Regulations Act, it is stated that where lamps are to be used they must be securely locked. The lock (so called) is a small screw passing through the lower part of the gauze portion of the lamp, and into or against the oil vessels. Such an arrangement can be overcome, and the light exposed with the greatest ease. It is quite certain that there is no one here who would consider any valuables they possessed secure if placed in a receptacle with a lock of this description as the only means of preventing their property being stolen. Yet it is placed on the lamp, and considered sufficient protection to the light, the exposure of which might cause a loss of life which, in value, cannot be compared to anything else. The rules affecting lamps provides that no instrument is to be taken down for the purpose of unlocking the lamps; but nails, wood, penknives, string, and many other appliances are generally at hand, and will effect the purpose of opening such a lock. I know of an instance where a lad opened a lamp with the corners of his shirt; and another, where the

lamp was locked by a man with his teeth; and a third, unlocked with a penknife. The padlock, when used, is little better and far more treacherous—they have been known to fall off; the simplicity of the lock is such that a bent wire or strong pin is used as a means of rapidly unlocking the lamp.

Locks in great variety have been invented; pneumatic, hydraulic, magnetic, lead plug, and spring lock, all have either failed in their supposed security, or else the screw lock is considered sufficient. If the locking of a lamp is of the slightest utility as a preventative, it should be so locked that neither master nor man can open it in the pit to expose a naked light. Considering the vast number of men and boys employed, the inducements that are at times, if possible, to open the lamp, such as losing his light, the wick fouling in the tubes, occasionally for a smoke, &c.,—that it is possible to do so without detection, and can be effected without difficulty,—it is not to be wondered at that tampering with locks so frequently occurs; more particularly when we consider such men may be practical colliers, and, in their own estimation, able to judge whether it is safe to open a lamp or not. Punishment may act as a deterrant and diminish this risk; but is no satisfaction to find, after an explosion and loss of life, that a lamp top is found separated from the bottom. The only plan to adopt is—cause the exposing of a lamp flame to be impossible, and this will tend towards safely lighting the colliery.

Knowing that the locks of lamps can be so readily opened, does it not cast a serious responsibility upon the management, if it is possible to securely lock the lamp, and yet continue a system that has so constantly proved a failure, simply because it has by custom gained the name of a lock, or because it is used by neighbours, or is the lock of the district? It is not long since, that some magistrates

remarked, in fining a man nominally for unlocking his lamp, that his punishment would have been more severe had it not been that others were to blame for allowing such a locked lamp to be used. This point is worthy of the most serious consideration of managers, as it neither carries out the letter or the spirit of the Act, and is an entire misnomer and an absurdity to call a screw a lock.

The portion of a complete safety lamp that is of the greatest value, and which has so far mainly baffled all attempts to perfectly secure, is the flame or power of giving light. In surrounding it with a covering, however clear, the rays of light are absorbed to some extent, the quality depreciated according to the construction of the lamp. It will be well known that with candles, gas, or oil, the production of a flame is the same. The application of heat ignites the hydro-carbon vapour. The oxygen of the atmosphere, of which it forms so small a portion, combines with the hydrogen, producing heat and raising to incandescence the particle of carbon giving the light. That the centre of the flame is filled with unconsumed vapour will be well known, and that the vapour is not consumed until it comes within the circle of fire surrounding it,—the results of the combustion of the hydrogen and carbon producing vapour and carbonic acid gas. It is worthy of note how beautifully nature supplies the needful amount of oxygen, and that the nitrogen of the atmosphere retards the more active and rapid combustion of the carbon which, if properly controlled and utilised, gives the greatest amount of light. This gives one to suppose that the results of combustion were intended to occupy a far more important part than they are usually assigned in the safety lamp. The various oils used in the safety lamps vary considerably in their composition. The relative proportion of hydrogen and carbon in connection with the amount of air to support combustion differ

very considerably, and it is of the utmost importance that the amount of carbon to be consumed is not too dense; otherwise the oxygen has more work than it can possibly effect with advantage,—depreciating the illuminating power of the light and the temperature of the flame. The complaint of bad oils, smoky flame, and crusting on the wick frequently arises from employing an oil too densely charged with carbon. On the other hand, when the supply of oxygen, and particularly when combined with hydrogen carburetted, causing the too rapid combustion of the carbon, it produces heat at the expense of light.

I give an example of this at the end of my paper, which was made some years since in the form of a comparative test by the spectroscope of two lamps, viz., Geordie or Stevenson lamps, constructed exactly alike as regards the top portion, but using two different kinds of oils. (I am indebted to Mr. Thomas Harrison for making this test.) The late Professor Willes, in preparing a paper for the Society of Arts, conducted some elaborate tests with the photometer to show the amount of light lost in passing through the covering of the different kinds of lamps. It will be seen from Table II. that the loss of light in the Davy and Stevenson is immense, and that the Clanny flame, although only surrounded by clear glass, lost as much as 28 per cent. when compared with the naked flame. Yet the Mueseler gained slightly when submitted to the same test.

The construction of the lamp accounts for this difference; in the Clanny the cold air rushes on to the top of the flame, reducing its temperature and light-giving power. Wherever the heated column of carbonic acid gas in the Mueseler lamp ascends the chimney, the air becomes heated in passing down the side of the glass, and assisting the flame at its lower part without cooling the light-giving rays.

The power of lowering the flame temperature of different

lamps to the point of extinction is also given in tabulated Form III. (To Mr. J. Longden, Blackwell Colliery, I am indebted.)

As a perfect combustion of the oils used gives the best results as regards the light, to a greater extent it improves the temperature of the flame.

To the heat of the flame depends the power of detecting gas, but as the presence of gas in small quantities shows itself in such a shadowy form, it is found necessary to reduce the light, so that its brilliancy may not obliterate the appearance of the halo which appears. But presuming there are two reduced flames of equal size, with a difference of temperature equal to 30 °/₀, whenever the flame with the lower temperature detects gas, the flame with the higher temperature will detect it more distinctly. If the proportion of gas is reduced to a point that the cooler flame will not show it, the other will do so most unmistakably. If therefore a flame can be used for detecting a smaller trace of gas than another, it should be adopted;—the smaller the trace of gas detected, the better for the safety of the colliery, always presuming the information will be acted upon by way of providing ventilation to dilute the air passing through the mine, beyond the power of detecting so small a trace of gas.

With reference to the vast number of tests that have taken place during the last twenty years, the reports of the Committee appointed by the North of England Institute of Mining Engineers, extending from 1863, and reported in their Transactions in 1867—experiments in Lancashire, Yorkshire, and elsewhere—were published at the time. The results of experiments in Belgium, and more recently in the adjoining district of Wigan, and which form part of the Transactions of this Society, are all worthy of investigation. It would be difficult to anticipate what will be the results

of the Royal Commission at present investigating the subject. But the only conclusion that can be arrived at so far is simply this, that at the present time the Davy and Clanny are thoroughly unreliable, both as regards withstanding the pressure of gas, methods of securing the flame, and quality of the light; that the Geordie, although slightly safer as regards the first-named quality, is no better than the Davy and Clanny; that the Mueseler is still an improvement, but not perfect as regards the severest forms of test, and also as regards light, is on the same footing of insecurity as the three named with regard to locking.

The addition of a Shield to the Davy does not improve its security, and a second or double gauze will only retard the time of explosion. The addition of a tin case, in improving its safety in one respect, depreciates its quality as regards light, which is already poor enough, and I fear will not give that security when submitted to exhaustive experiments as regards its power to withstand the pressure of gas; but, on the contrary, after the burning gas is maintained a sufficient time, explode in the same way that a lamp with a cylinder of glass from top to bottom outside the gauze will.

An ordinary Davy will explode at and over 5 feet per second; with a jet of coal gas allowed to play upon the gauze, the flame can be abstracted from within the gauze; with a jet of pure hydrogen gas a flame can be obtained from the wick without heating the gauze to any extent. Again, if this lamp is placed in a tin case with only one opening to allow the passage of a stream of hydrogen gas, and covering the top with a piece of cardboard or thick paper, an explosion will take place. With the Clanny and Stevenson, they will only to the extent of 4 or 5 feet per second extra velocity retain their safety; and when tested with hydrogen gas, are no safer than the

Davy, and with an ordinary coal gas jet the flame can be abstracted.

My connection with the subject of safety-lamps is now of some years' standing, and it was entirely owing to the numerous accidents and large loss of life from explosions taking place some years since, that I was led to consider the subject, and since then have practically devoted the whole of my time to it. The first part undertaken was the lock, and the principle adopted was to follow nature as closely as possible: deprive the flame of air and it dies. After many failures in bringing mechanical arrangement to bear, the lock now known as the Protector resulted. Its security lies in the fact that to open the lamp can only be effected by unscrewing the lamp, and in performing this operation the light is extinguished. There is no key, no means of getting at the bolt unless the light is out and oil vessel removed. In perfecting the lock it was absolutely necessary to dispense with the pricker, otherwise it only required the wick to be pushed up far enough to overcome the length of the extinguishing tube, or else necessitated the tube being increased to an impracticable length. Having adopted an oil that did not require the wick to be raised or consumed, it naturally followed that the wick should be permanent, and merely use it as the means of feeding the lamp by capilliary attraction, and from time to time as necessity required, such as the top of the wick becoming hardened and charred is replaced by a small bit of cotton. The use of this oil gives security far beyond what appears at first sight, and although it has met with much opposition, principally arising from a want of due consideration, it is daily gaining converts, and will be found one of the main elements of safety in a lamp that at present stands unrivalled. As used in the lamp is far safer than any other description of oil, the points of safety are briefly dispensing with pricker and inability of

user to interfere with the wick, the brilliancy of the light doing away with the main inducement for any one to open his lamp, the absolute impossibility of the oil to adhere to gauze of lighted lamp, and its consequent risk, the character of the flame being such that when subjected to rough treatment, or receives a blow accidentally, fall of coal, falling of the lamp, such as would damage the lamp, the light is certain to go out. If the lamp is not treated properly the result is the user is left in the dark. The temperature of the flame detecting the presence of a smaller percentage of gas, and above all, the more rapid combustion of gas when met with producing that excess of carbonic acid gas which, if properly utilised by the construction of the lamp case, will not only prevent explosions, but also render impossible the existence of a flame in an atmosphere of gas, thus securing the safety of the mine and practically compelling the most perfect ventilation of the pit if it is to continue working.

A comparison of the lamp submitted resembles, to some extent, the Belgium Mueseler. In the Protector Mueseler, the form of the chimney is almost conical, having a slight depression to receive and attach the gauze to. The base of the chimney projects but slightly below the gauze, and is not enlarged, whereas with the Belgium Mueseler the chimney descends far down, and is enlarged at its base. This is decidedly a weakness in the lamp, as the combustion chamber does not become perfectly filled with carbonic acid gas, and the flame can be maintained at a greater angle, just in proportion as the base is enlarged, so that the lamp may fail at its greatest need, as described by the report of the Belgium Commission. Another point worth notice, and, in my opinion, to be avoided, is the disconnected parts in the Belgium lamp,—allowing the glass and rings, gauze ring, chimney, and gauze to follow the unscrewing of the lamp—

requiring extra care in putting together to prevent the different parts being inefficiently fitted. In perfecting the lamp brought before your notice, every care has been taken that such parts as the outside of horizontal gauze, edge of outside gauze, and glass plate, must be so fitted and screwed together as to prevent any part unseen becoming unsafe, otherwise the lamp bottom and the protecting lock cannot be attached so as to pass the most cursory inspection. The use of asbestos washers to provide for expansion and contraction of the glass, and the use of a lead pin simply applied and clamped, without interfering with the regulation of the flame, is the means of detecting any attempt to tamper with the light, although not as a means of preventing the lamp from being opened. I have referred to the possibility of the horizontal gauze being improperly fitted, and the outlet of the chimney being enlarged. This has been provided for in the following way, and will be found a complete and effective preventative in such a contingency. The gauze on the table will best explain by inspecting the means taken. The space between the chimney and gauze is filled with substances of irregular shape, of a non-combustible character, so that, in the event of the horizontal gauze being overcome or defective, and allowing the flame to pass into the upper portion; it meets with obstruction in travelling upwards, and is attenuated in passing through the interstices, leaving behind in its passage carbonic acid gas, and preventing the downward passage of the flame, even if not cooled down to point of extinction. This arrangement could be carried to the top, but I prefer to insert a metal box or gas trap with an opening at its base to fit on chimney, and cover the same with gauze. The object of this is to provide for the slightest chance of the flame passing up the chimney, the results of combustion are carried up under ordinary circumstances, and some portion falls over, filling the box surrounding the top of chimney, so that if the flame passed upwards by any

means it is a matter of impossibility for it to exist beyond the outlet. It also offers a resistance to any pressure, and strengthens the lamp materially. It will be noticed that all throughout the details of this lamp the principle of safety may be summed up in utilizing natural results,—mechanical action of unscrewing the lamp, depriving the flame of support and destroying it.

The action of an explosive mixture on the flame, producing carbonic acid gas in excess, which in turn prevents the continuation of combustion.

The arrangement of this lamp, independent of the provision made for preventing the flame passing into the spaces between the chimney and gauze, is at present used in a large number of collieries with the greatest success. The severe tests the lamp has stood in collieries that are subject to frequent outbursts of gas without causing any inconvenience beyond extinguishing the flame as the gas passed them, has given those in charge of such collieries the greatest satisfaction. And in their opinion, after investigating the result of such outbursts, that had Davy or Clanny lamps been used, in all probability an explosion would have taken place, with loss of life more or less disastrous. However safe lamps may be made, unless the treatment they receive, and the conditions they are under, before they are placed in the hands of the user, is very different from what is too frequently the case, it is certain that they will not give that security so much desired. The lamps should be the property of the proprietors of the colliery. A lamp-room of sufficient size on the surface, properly fitted out with appliances for purposes of cleaning and trimming lamps, should be provided. The responsible man in charge should be one that can be relied upon, and nothing will assist in improving the safe lighting of collieries more than raising the position of this official, and placing men in charge of a superior class than are generally to be found fulfilling this duty.

Much could be said respecting the best system to be pursued, and which might be carried out without adding materially to the cost, if only the customs and prejudices of by-gone years could be dispensed with.

The loss of light underground might safely be provided for by supplying spare lamps locked and lighted, with flame reduced to small size, at convenient stations, without running the risk that always exists where lamps are relighted and locked underground. If a lamp from its construction can be examined in all its main parts, and the principal lampman held responsible for the condition the lamps are delivered to the men, it is only reasonable the lamps should be returned in the same condition as regards locking they were sent out in. Each man who uses a lamp should be impressed with the importance of examining his lamp before he descends, and, if found with a defective lamp in the pit, held responsible. The inspection of the lamps at the bottom should be more real and less a matter of course than it is generally, and also as each working place is visited an examination should take place.

In conclusion, it must be admitted that if explosions are to be prevented, in addition to all known means of laying out and ventilating collieries, providing for what may be expected, the best mechanical means must be adopted as a precaution against the unexpected, whether it arises from carelessness, recklessness, not complying with regulations, or from causes which no human being can foresee.

In avoiding reference to any particular cases that have come under my notice during the last ten years, although many startling instances might be referred to where explosions have been disastrous both with regard to loss of life and property, the numberless narrow escapes, if known, would induce many to lose no time in endeavouring to improve the safe lighting of collieries.

TABLE I.

TESTS BY THE SPECTROSCOPE.

Spectrum of Protector Lamp.

Rays.	Without Gauze.	With Gauze.
Red (Heat rays)	100	90
Orange (Partial light and heat)	100	85
Yellow (Light)	100	80
Green (do.)	100	70
Blue (do.)	100	60
Indigo (Actinic)	100	30
Violet	100	none
	700	415

Thus, 70 per cent. of the light passes the gauze.
15 per cent. of the Actinic rays.

Spectrum of the Oil (Geordie) Lamp.

Rays.	Without Gauze.	With Gauze.
Red (Heat)	100	45
Orange (Subdued light)	100	70
Yellow (Light)	100	60
Green	100	45
Blue (Partly light)	100	35
Indigo (Actinic)	100	25
Violet	100	25
	700	305

About 47 per cent. passes. 25 per cent. Actinic rays.

RELATIVE POWER OF BOTH LAMPS.

	Protector with Gauze.	Oil.
Red	100	45
Orange	100	85
Yellow	100	100
Green	100	50
Blue	100	45
Indigo	100	25
Violet	none	none
	600	350

The oil lamp gives off 30 per cent. less light, being a gain in favour of the Protector lamp of about one third more.

The oil lamp gives out less than one half the actinic rays.

In addition to the foregoing observations I found that the oil lamp gave a double line in the yellow ray, proving the presence of sodium, and to some extent an imperfect combustion, whilst the Protector lamp gave an unbroken continuous spectrum throughout.

In testing with explosive gas $H_2.O$. I found the new lamp very sensitive, much more so than the oil lamp. The new lamp was immediately extinguished. The oil lamp two or three spurts previously.

LAMP TESTS MADE AT BLACKWALL COLLIERY, MAY 23RD, 1877.

By Mr. J. Longden.

Description of Lamp.	Photometer No. of Lamps = 1 Candle.	Height of Flame.	Diameter of wick. Asbestos makes the flames greater diameter.	Cubic feet of air per Minute.
		Inches.		
Clanny naked light ..	$\frac{7}{8}$	$1\frac{1}{2}$	$\frac{9}{32}$	3·200
,, with top on ..	$1\frac{1}{4}$	$1\frac{1}{2}$	$\frac{9}{32}$	not out.
Jack naked light	$1\frac{1}{4}$	1	$\frac{9}{32}$	2·600
,, with top on	$1\frac{3}{4}$	1	$\frac{9}{32}$	went out.
(This lamp is like Davy)				
Mueseler naked light..	$1\frac{1}{2}$	$\frac{7}{8}$	$\frac{9}{32}$	3·200
,, with top on ..	$1\frac{1}{2}$	$\frac{7}{8}$	$\frac{9}{32}$	not out.

Remarks.—The Mueseler burned the brightest at 3·200 feet per minute. Flame the maximum, without smoke in all cases.

Photometer Test by Professor Wills.

Standard 1·0 sperm candle burning 120 grains per hour.

	Without gauze and glass.	Complete.
Oil Clanny burning colza oil	·419	·351
Protector do. ,, colzaline.....	·850	·610
,, Mueseler ,, ,, ...	·748	·746
,, Davy ,, ,, ...	·896	·329
,, Jack (with glass surrounding gauze) ,, ...	·896	·247

I would remark that a flame surrounded by a Davy gauze will lose about 63 per cent. of light. If the gauze is surrounded by glass in addition about 72 per cent. Clanny 21 per cent. to 28 per cent., according to the clearness of the glass. Whereas the Mueseler regains the loss of light by the absorption of the glass, owing to the construction of the lamp causing it to have more

perfect ventilation, and, in consequence, more perfect combustion. The position of the lamps therefore stand thus,—it takes about

6	Davy oil lamps to equal 1 sperm candle.				
9	,, ,, with glass cylinders, to equal 1 sperm candle.				
6	Stevenson oil lamps	,,	1	,,	,,
3	Clanny ,,	,,	1	,,	,,
3¼	Davy Protectors, with gauze	,,	1	,,	,,
4	,, ,, with glass cylinder	,,	1	,,	,,
1⅔	Clanny ,,	,,	1	,,	,,
3⅛	Stevenson ,,	,,	1	,,	,,
1¼	Mueseler ,,	,,	1	,,	,,

The discussion upon the paper was postponed to a future meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XV. VOL. XVI. SESSION 1881-82.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 4th day of April, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

GEORGE GILROY, Esq., M.INST.C.E., President, in the Chair.

NEW MEMBERS.

Mr. THOMAS WALLWORK, Bridgewater Collieries, was proposed, balloted for, and duly elected an ordinary member of the Society.

A NEW GAS DETECTING APPARATUS.

Mr. TEALE exhibited and described an apparatus invented by Mr. Jones, of the Ebbw Vale Co., for detecting gas in remote and inaccessible corners in mines. It is on the principle of a syringe and arranged so that the air drawn in is compressed, and through a small tap allowed to enter a safety lamp when desired.

The CHAIRMAN and other gentlemen criticised the invention, the utility and safety of which was to some extent doubted.

THE KŒPE SYSTEM OF WINDING.

The discussion was resumed upon the paper read by Mr. Percy at a former meeting on "The Kœpe System of Winding."

Mr. PERCY said that he had little to add to the information contained in his paper, read two months ago. There was present, however, a gentleman representing the firm of Messrs. Nasmyth, Wilson and Co. (Mr. Muir), who were the responsible parties, in this country, in connection with the Kœpe system, and that gentleman would give the meeting any information which might be desired.

Mr. RIDLEY MUIR said that on behalf of Messrs. Nasmyth, Wilson and Co. he should be glad to answer any questions addressed to him by gentlemen who desired information.

The PRESIDENT: Will you kindly tell us how long it has been at work, and where it is at present worked, in this country?

Mr. MUIR: It has been working at the Bestwood Collieries about twelve months. It is not at present at work elsewhere in this country, but we hope it shortly will be.

Mr. MARTIN: Some of the members raised a question at the former meeting with reference to the possible slipping of the ropes, and consequent change of position as regards the indicator. Mr. Percy, at that time, pleaded want of personal experience in the matter, and could not undertake to answer the question.

Mr. MUIR: With regard to the slipping of the rope there was some little difficulty experienced at first, but we have overcome it now completely. We suspend the cages in such a manner that when they are dropped upon the catches the catches take the weight of the cage, but the weight of the landing and balance ropes remains upon the pulley; so that

it still has the weight of all the ropes down in the pit in the groove of the pulley to prevent it from slipping. This has been found quite sufficient.

Mr. MARTIN: There was another point, I think, with reference to the safety ropes.

Mr. MUIR: That, I think, was not quite understood by Mr. Percy. There is a block of wood placed immediately underneath the safety pulleys, and the bearings of the safety pulleys are supported on springs which are sufficiently strong to sustain the weight of the safety pulleys and safety ropes themselves; but, in the event of the winding rope breaking, the ropes and cages—and the coal in the cages—come on to these safety ropes; this compresses the springs, and then the safety pulleys come down to the block of wood—like a break block placed immediately below—which arrests the pulley from turning, and so prevents the cage from dropping down the pit. I had expected there would have been some diagrams by which I might have explained it.

Mr. J. S. BURROWS: Has that ever been tried?

Mr. MUIR: Yes; upon the Continent several times.

The PRESIDENT: That is to say, it has been put to a practical test?

Mr. MUIR: It has.

Mr. MARTIN: May I ask in how many places on the Continent this system is at work?

Mr. MUIR: I really cannot say how many.

Mr. MARTIN: Is it in use universally, or at all extensively?

Mr. MUIR: It is used very extensively in Prussia; all of Krupp's mines are worked on the Kœpe system.

Mr. MARTIN: I believe the Hanover Colliery, in Westphalia, situated seven or eight miles from Essen, was the first where it was put in practice.

Mr. MUIR: I am not prepared to say whether that was the first or not—possibly it may have been.

Mr. Martin: When erected a difficulty arose with reference to workmen riding on the ropes. In Prussia, colliery owners cannot allow workmen to ride upon the ropes without special permission—in fact, it is not allowed by law: and, if I recollect rightly, there was some difficulty with the mining authorities with reference to obtaining that permission for this arrangement. Can you say whether the difficulty has been overcome or not?

Mr. Muir: I cannot say. Mr. Wilson, jun., meant to have attended this meeting, and I have no doubt he could have given the information desired, as he has been in Prussia. Unfortunately he is at present from home.

Mr. Martin: I know the colliery where this system of winding was put in use: but it had only just come into notice, and was adopted at that colliery after I left the neighbourhood. I do not know, therefore, the practical details of it.

Mr. Muir: Mr. Wilson, jun., has been there, and I am sure he would have been able to answer your questions.

Mr. Martin: At the former meeting information was requested with reference to the working of the balance rope. Mr. Winstanley said that at Bestwood they had had difficulty through the rope twisting and coiling in the sump hole.

Mr. Muir: We heard of some slight difficulty at one of the Bridgewater collieries not long ago; we suggested that they should let the balance rope be made longer so as to run in the water at the bottom of the sump. That effectually stopped it. But we have details of arrangements for applying pulleys at the bottom for the rope to pass round, if any difficulty of that sort should arise again. At Bestwood they found no objection at all.

The President: They worked without the pulleys?

Mr. Muir: They did.

Mr. Martin: Is the rope made peculiar in any way?

Mr. MUIR: No; any ordinary rope will do. There is no peculiarity at all in the ropes in use.

Mr. MARTIN: Then Mr. Pilkington asked with reference to the capping—in case the capping became damaged,—there was no way by which the rope could be recapped or lengthened.

Mr. MUIR: We have an allowance of 2 ft. at each end, above each cage, for adjusting the length of the rope. But there is no fear of the rope getting damaged at the capping so much, because with the arrangement we use, when the cage is dropped on the catches, the rope still remains tight; it never doubles at the capping, which I believe principally wears a rope out—its becoming loose and falling down; but with the arrangement described that is obviated entirely.

Mr. MARTIN: In that case, would not a short chain at the end of the rope be useful?

Mr. MUIR: A single link chain to vary the length of the rope could be applied, if desired.

Mr. MARTIN said that at the former meeting Mr. Woodward enquired as to the possibility of accident from over-winding.

Mr. MUIR: With regard to over-winding, the cross-head to which the cage is attached is made strong enough, so that if over-winding takes place, the cross-head comes against the stop, and at the same time the cage which is down the pit comes on the stops at the bottom, so that it takes the weight of that cage off the pulley, and then the drum slips round the cross-head holding the rope from coming over the head-gear.

Mr. J. S. BURROWS remarked that with the whole weight of the cage in the head-gear, and the rope on the other side, it seemed to him that a considerable portion of the load would still rest on the pulley.

Mr. MUIR: The cage coming on the stops at the bottom

relieves it of a certain amount, and you will allow that it makes it easier to slip than if the whole weight was upon it. No doubt the power of the engines is sufficient to slip the pulley round on the rope if the cross-head comes against the stop, at the top of the head-gear, whether the bottom cage is in the catches or not. The friction would not be sufficient to break the rope.

In reply to a further question by Mr. Burrows,

Mr. Muir said that the safety ropes were entirely distinct from the system; they could be applied or not, as desired. It was merely suggested as an efficient safety apparatus.

In reply to the President,

Mr. Muir said they have got the safety ropes in use now at Bestwood.

Mr. Burrows: Would not you want to cap the rope sometimes, so as to change the position on the pulley? Supposing you put a cap on the rope, and let it stand two years, you would have the same place in the rope on the pulley the whole time? By cutting two yards off the rope, you get another portion of the rope over the bend of the pulley. If it were to stand in exactly the same position upon the pulley for some months the rope might be seriously damaged.

Mr. Muir: The rope is on and off the pulley every time the engine moves.

Mr. Burrows: But when the engine is standing the same portion of the rope is on the pulley.

Mr. Percy: I do not think the mere fact of the rope being upon the pulley when the cage is at the bottom has anything to do with the long or short life of the rope. The Kœpe system enables you to coil your rope always round a circumference of the same dimensions, both on the pulley and drum; your rope is always working in the same line, and you have no side friction. I contend that a good

capping ought to last as long as the rope itself, and that it is not the pull on the capping which causes the necessity for the capping being renewed. It is the buckling occasioned by a load being let down and taken up again: in the Kœpe system you have always the same weight of load on the capping, and there is not that inequality which will injure the rope.

Mr. Burrows: We do not take the capping off the rope because it is bad, but to shift the position of the rope upon the pulley. If it is allowed to remain always in the same position the rope will be deteriorated by the penetration of moisture between the wires, causing rust.

Mr. Percy: If Mr. Burrows argues that the re-capping of the rope, when the capping is good, is for the mere purpose of changing the position of the rope on the pulley I cannot follow him. So long as the two cages are in the right position with regard to each other my experience has always been that the capping is best let alone, as long as it is good. In the Kœpe system every part of the rope had the same amount of work to do.

Mr. J. Orchard supported Mr. Burrows's view as to the desirableness of re-capping the ropes periodically, whether they actually needed it or not. The ropes, he said, when several months in use frequently showed some little corrosion inside near the capping.

The President: If I understand Mr. Burrows rightly, he attaches importance to the ropes being always in one position on the pulleys. There is a constant action of the rope on the pulley, and he attaches great importance to its not wearing always in one place when the tubs are changing. It is not altogether the extra weight, or anything of that kind, but the mechanical action of the rope on the pulley at all times. That, I think, is what Mr. Burrows means.

Mr. Burrows: Yes; that is it. Would it be possible to

obtain any statistics as to the comparative length of life of a rope on the Kœpe system and on the ordinary system?

The PRESIDENT: I suppose it has not been long enough in use in this country.

Mr. MUIR: I am not prepared with any information upon that point; but I believe Mr. Wilson has statistics as to the length of life of ropes on the Continent. In this country the system has not been long enough in use. With regard to the deterioration of the rope, owing to the same portion always being exposed to the weather at the top of the head-gear during the night time, and when standing; the Kœpe system affords every facility for varying the portion of rope exposed, without resorting to re-capping for that purpose, for the weights on each side of the pulley being equal when no coal is in the cages, it is not necessary that one cage should be drawn up to the top when leaving off work, the cages may be left hanging in any position in the shaft, so that the particular portion of rope left exposed at the top can be varied every night if desired.

GEOLOGY OF PIC DE SANCY MOUNTAINS, CENTRAL FRANCE.

By W. J. BLACK, F.R.S.C.E., &c.

(Abstract of Communication.)

Dr. Black described the Monts Dore, in central France, which had been formed by volcanic eruption, and consisted mainly of a large cake like mass, about 15 to 20 miles across, and 6186 feet in height at Pic de Sancy. Its surface was cut up by numerous ravines and valleys, radiating outwards from the centre, in which were various well known hot and cold mineral springs, as Les Bains, Bourboule, St.

Nectaire, &c. This eruptive mass had a different volcanic character from the extinct cinder cones further north, as its lavas were in sheets, its craters were pits, and it was formed ages before the modern volcanoes of Auvergne. The order in which these beds were stated to be laid was that the Granite flowed over the Gneiss and Schists, then followed the Basalts, and lastly came the Trachytes over all, with conglomerate Trachytes intercalated. The origin of these conglomerates has been a frequent subject of discussion, and some have thought them to be of glacial nature, but others regard them as volcanic breccias, or imperfectly fused lavas. Its volcanic activity had also been different from them, as the Basalts and Trachytes were poured out of the vents in silent streams over the surrounding country without explosions or clouds of vapours, or showers of ashes. This action is presumed to have been brought to an end by earthquakes rupturing the overlying beds at the various ravines, and removing the summit mounds, as that of the Pic de Sancy by bursting dislocation. After its cessation the modern cinder volcanoes broke out round its confines in many places, and kept up their action under the supplies of water they got from the neighbouring crater-ponds and valley-lakes formed in the previous era. They finally also became extinct when these pits and basins got filled up by falling debris and their contents drained off into the rivers below. This was pointed out in the cases of the Puy de Mont Chalme and Lac Pavin, and of Mont Tartaret and the Lac Chambon, and of several others in the district. The physical appearance of the Mont Dore country supports the idea that it had been visited by the glacial eras two or three times, but as yet there has not been found much structural evidence, neither till, furrowed-rocks, or grooved boulders. Such evidence has been found further east in the Rhone valley, and further examina-

tion is much required in the Mont Dore district to establish this point on its denudation.

A collection of minerals gathered at the various localities spoken of in the district, photographs, and sketches of the scenery were exhibited, along with explanatory charts; and geological sections of the Monts Dore were also shown, drawn according to the scale from modern surveys, illustrating the views of the author on their structure.

Mr. STIRRUP, who had visited the district described by Dr. Black in the year 1876, made some observations upon the paper, and stated that he could not agree with the whole of the conclusions which Dr. Black had arrived at. The geologist who wished to study the phenomena of the district should go there without any preconceived ideas, and should follow the example of Mr. Scrope and reside there for some months, or it might be for years. Justice could not be done to the subject by a mere casual visit.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVI. VOL. XVI. SESSION 1881-82.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 2nd day of May, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOSEPH DICKINSON, Esq., F.G.S., Vice-President, in the Chair.

NEW MEMBER.

WILLIAM S. GRESLEY, F.G.S., Overseal, Ashby-de-la-Zouch, was proposed, balloted for, and duly elected an ordinary member of the Society.

The following are the recent additions to the Library:—

American Museum of Natural History: Bulletin, No. 1, Dec., 1881.—*From the Museum.* Belfast Natural History and Philosophical Society: Proceedings for Session 1880-81.—*From the Society.* Canada: Report of Progress of Geological and Natural History: Survey for 1879-80.—*From A. R. C. Selwyn, F.R.S., on behalf of the Canadian Government.* Devon and Exeter Free Library: Report, 1881-2. Edinburgh Royal Society: Proceedings, Vol. XI.; Nos. 108-9: Session, 1880-1.—*From the Society.* Geological Magazine. London, Nos. 214-215. 1882.—*Purchased.* Geologists' Association. London: Proceedings, No. 4, Vol. VII.—*From the Council.* Glasgow Geological Society: Transactions, Vol. VI., Part 2.—*From the Society.* Institution of Mechanical Engineers: Proceedings, No. 1, 1882.—*From the Institution.* Liverpool Geological Association: Trans-

actions, Session 1880-81.—*From the Association.* Midland Institute of Engineers: Transactions, Vol. VII., Part 57.—*From the Council.* Mining Institute of Scotland: Transactions, Vol. III., Part 12; Vol. IV., Part 1.—*From the Council.* North of England Institute of Engineers: Transactions, Vol. XXXI., Parts 1-2.—*From the Council.* Oxford Catalogue of Books added to the Radcliffe Library.—*From the Librarian.* Royal Institution of Cornwall: Vol. VII., Part 2.—*From the Council.* South Wales Institute of Engineers: Proceedings, Vol. XII., Part 8.—*From the Institute.* Victoria: Reports of the Mining Surveyors for Quarter ending December 31, 1881.—*From the Royal Society, N.S.W.* Yorkshire Geological Polytechnic Society: Proceedings, N.S., Vol. VII., Part 4.—*From the Society.* Lectures on Mining, by J. Callon: Translated by Messrs. C. Le Neve Foster and W. Galloway, Vol. II., with Atlas.—*Purchased.* Berg, Hutten, and Salinen-Wesen: Zeitschrift, Vol. XXIX, 1881.—*Purchased.* Der Deutschen Geologischen Gesellschaft: Zeitschrift, Band XXXIII., Heft 4, 1881.—*From the Society.* L'Académie Imperial des Sciences de St. Petersbourg: Mémoires, VII$_e$ Serie, Mémoires, Nos. 3-4, Tome XXIX.; and Nos. 1-2, Tome XXX.; Bulletin, No. 4, Tome XXV.—*From the Academy.* Società Toscana di Scienze Naturali: Processi Verbali, Vol. III. (pages 29 to 92), 1881.—*From the Society.* R. Accadamica dei Lincei: Transuntis, Vol. VI., Fas. 8°, 9°, 10°.—*From the Academy.* M. M. Dewalque and Dupont. Brussels: Pamphlets: Sur l'origine des Calcaires Devoniens de la Belgique.—*From the Authors.*

FLINT IMPLEMENTS.

Flint implements shown and described by Messrs. Law and Horsfall to the members of the Society in February.*

The following remarks from the authors of the paper have been addressed to the Hon. Secretaries:—

"In reply to the discussion on our paper, we are sorry we cannot accept the views of those gentlemen who have criticised it. Looking at the matter with an unbiassed mind, we cannot alter our opinion that those flints belong to a period prior to written history. The specimens on the table would be noticed as serrated at the edge with use, not sharp as when knocked off the core. What are

* See Part Trans. XIII., Vol. XVI.

called in the discussion 'strike o' lights' are figured by Mr. John Evans as skin scrapers and cores.

"It is not likely that so many as eighteen strike o' lights would have been lost on a space of ground eight or nine yards square. We found this number of cores and scrapers on March Hill on that space of ground. We consider that the freshness of flints depend upon the material they are embedded in. If embedded in a sandy subsoil and blade earth they are not likely to look as old as those buried in material containing oxide of iron, which would coat them over and give them an antique appearance. Some of the flints shown have been found *in situ*, embedded two or three inches in the subsoil below the peat, which averages from one to five feet in thickness on highest hills in ten districts where vegetable matter must have accumulated slowly."

THE CHANNEL TUNNEL.

Prof. W. Boyd Dawkins, M.A., F.R.S., brought the question of the Channel Tunnel before the Society. He said: I am here this afternoon to put before you a few general considerations relating to a burning question. It has so happened that it has fallen in my way, as the member of the scientific committee entrusted with the geology, to study the proposed channel tunnel rather more minutely than most people have been able to do. I therefore thought that it would not be improper if I placed before the Manchester Geological Society a few of the conclusions to which I have come regarding a matter that is almost of universal interest. In the first place I would wish to point out that various schemes have been proposed, from time to time, for bringing this country into more intimate connection with the Continent than it is at the present day. The first scheme which I would mention is that of M.

Mathieu, in the days of the First Consul. He proposed, at the close of the last century, the making of two galleries, the upper for horses to gallop through, while the lower gallery was to be used for purposes of drainage, and he estimated that the space between England and France could be galloped over by horses, relays being provided at suitable places, in about one hour. This is the first idea on record of uniting this country with the Continent by means of a tunnel. The next scheme was one advanced by an eminent French Engineer, M. Thomé de Gamond. In 1834 he proposed the laying down of an iron tube to connect the two countries, and in 1857 he came to the conclusion that the best means of communication would be offered by a tunnel. He spared neither time nor trouble in working out that idea. He came over to this country and had interviews with various distinguished persons, including the Queen and the Prince Consort; and so interesting is the account which he gives of his interview with the Prince that I will read you the following extract:—

"The first time that we had an opportunity of talking to Lord "Palmerston on the subject of the Submarine Tunnel we found "him at first rather close. 'What! you pretend to ask us to "'contribute to a work, the object of which is to shorten a distance "'which we find already too short.'

"We expressed to him our wish to talk of it to Prince Albert "in his presence, and to this he very kindly consented. The "Prince Consort had supported this project with truly enthusiastic "sympathy. His reception was, therefore, most kind. He entered "into conversation, in which the Prince unfolded all the advan-"tages which his elevated mind foresaw for England in the "creation of a road to the Continent.

"Lord Palmerston, without losing that perfectly courteous tone "which was habitual with him, made, however, a remark to the "Prince which was very rude at bottom. 'You would think "'quite differently if you had been born in this island.'

"We were ourselves perfectly stupified with this unexpected "apostrophe. To make Prince Albert, whose love of the country

"of his adoption was well known, feel that he was a foreigner "was shocking to us, and we felt deeply hurt.

"Some days after we went to excuse ourselves with the Prince "Consort for having been the cause of this disgraceful incident. "The Prince appeared not to have been offended, and told us that "he had received this innocent dart as one of the frequent sallies "in which Pam dealt. Then he added that he had said a few "words about the Submarine Tunnel to the Queen. Her Majesty "had been graciously pleased to answer him in these good words: "'You may tell the French engineer that if he can accomplish it "'I will give him my blessing in my own name, and in the name "'of all the ladies of England.'"

In those days there was no sign of that sentimental objection to the scheme which is now present in the minds of some eminent men in this country, although it was opposed by our illustrious Palmerston—who was a perfect example of an insular Briton. The idea of a tunnel was then, popular. In 1868 a petition was presented to Napoleon III., asking for "your Majesty's support for the construction of a submarine tunnel intended to connect the railways of England with those of the Continent,—an eminently desirable work which has become necessary to facilitate the social intercourse which has so rapidly increased of late years between the inhabitants of France and England, and for the development of their trade and commerce." The numerous signatures attached to it belong to men of all shades of political opinion, and nearly all versed in practical affairs. They include the Archbishop of York, the Dukes of Sutherland and Argyle, an Earl, the Marquis of Lorne, twelve Lords, eight Baronets, two Major-Generals, one Admiral, and fifty-three Members of Parliament. Among them we may mention Lord Frederick Cavendish, Sir Thomas Bazley, Messrs. Bernard Samuelson and Jacob Bright, Henry Rawson, Chairman of the Manchester Stock Exchange; and J. M. Bennett, Chairman of the Manchester Chamber of Commerce. There was then no sign of dissent on the part of those who now oppose the idea

of a tunnel on patriotic grounds, a circumstance which may perhaps be accounted for, not by the development of their patriotism since that time, but by the fact that the *Nineteenth Century* had not then come into being.

M. de Gamond did not only make the undertaking popular among people of rank and position. He actually had the hardihood to allow himself to be lowered down into the Channel itself; he dressed himself up in a diver's dress, and he had—the last time that he went down—a most extraordinary fight with some immense conger eels, which did not let go their hold till he reached the surface. (Laughter.) I mention this in order to show that M. de Gamond was in earnest. Whatever credit there may be with regard to putting this matter on a practical basis, is to a large extent due to those preliminary investigations which he carried on.

In 1867, an English engineer at Wrexham, Mr. Low, proposed a double tunnel, and his project was approved by the Emperor Napoleon and some of his chief Ministers. In the year 1864-65 Sir John Hawkshaw undertook some inquiries bearing on this matter, and in 1875 the Channel Tunnel Co. (Limited) obtained an Act of Parliament, empowering preliminary experimental operations to be carried out at St. Margaret's Bay, to the east of Dover. A boring was made, but the works were not carried on, and up to the present time no further works have been carried on in that place. On the French side, however, the project of the tunnel met with considerable support, and in 1874 a concession was obtained from the French Government by M. Michel Chevalier, M. Lavalley, M. Raoul Duval, and the other gentlemen composing the French Tunnel Company; the enterprise formed the subject of an exchange of notes between the French and English Governments, and was approved by the latter. At that time, the Conservatives

being in power, Lord Derby, then Foreign Minister, wrote as follows to Lord Lyons:—

"Of the utility of the work in question, if successfully carried out, there appears no room for any doubt, and Her Majesty's Government would therefore offer no opposition to it, provided they are not asked for any gift, loan, or guarantee in connection therewith." (Dec. 24, 1874. Correspondence respecting the Proposed Channel Tunnel and Railway.—Parliamentary Blue Book Commercial No. 6 (1875) p. 16.)

Up to that time there was no outcry as to our country being imperilled; there was no banding together of people of various ranks, and of various callings in life, crying out that they were afraid this country would be seized by the foreigner. If we compare the quietness of public opinion at that time with the wave of sentimentality now sweeping over the country, it is a very remarkable contrast indeed. On the French side, on the basis of the approval of the English Government, the French Channel Tunnel Company have carried on the survey of the bottom of the sea, and have collected the data which have been necessary to be collected for the enterprise: they have also spent a very large sum of money on works. On our side nothing was done until the year 1881, when an Act was obtained by the South Eastern Railway Company, giving them additional powers to those they already possessed for the purpose of making experimental borings and other works, in connection with a submarine tunnel. Those works were at once set on foot between Folkestone and Dover; and the Submarine Continental Railway Company was incorporated at the beginning of this year, with our townsman, Sir Edward W. Watkin, for its chairman, by whose energy and determination the enterprise will in all probability be carried to a successful issue. I have already mentioned that the rival scheme for starting a tunnel at St. Margaret's Bay was not carried out. In its place the Channel Tunnel Company

have asked Parliament for powers to start a tunnel from Fan Bay, one and a half miles nearer Dover. Thus there are two rivals for the honour of connecting Britain with France, eager—according to some—to undertake a great enterprise for the good of commerce and the spread of good will, or, according to others, ready to sacrifice their country without remorse.

Into the general question of the advisability of the tunnel I do not intend to enter. It is necessary to put before you these details in order that you might be made acquainted with the present position of affairs. It is the geological aspect of the question that I wish to bring before you this afternoon, and in the first place I would point out to you the sections of English cliffs from Folkestone to St. Margaret's Bay. At the base you have the gault, a clay impervious to water, and above that a very thin layer of chalk marl, or, as it is sometimes termed in the older books, Upper Green Sand, ranging from about 3ft. to 15ft. in thickness. Above is a very considerable thickness of grey chalk and chalk marl, averaging 225ft. in the cliffs between St. Margaret's and Folkestone. [Prof. Dawkins exhibited samples of this chalk, showing the transitions of colour from dark to light, according as the samples were taken from the bottom or from above.] Above that, we have white chalk, without flint and much more porous and open than the chalk below, about 145ft. in thickness. These beds represent the lower chalk, white and grey, Then, above that, comes the chalk with a few flints, and above that again the nodular chalk with many flints, and higher still the St. Margaret's Bay chalk. These compose the upper chalk, and average 480 feet in thickness.

The water-bearing capacities of these rocks must first be considered. In the first place the lower chalk marl, ("Upper Green Sand," of old authors,) is for the most

part without water. In some few places, however, I found a little water—mere weepings—where the sand predominated. It is exceedingly irregular in its thickness and sometimes assumes the condition of a hard and white clay, full of green grains. The lower portion of the grey chalk, including upper chalk marl which is lithologically of the same character, is for the most part, though not quite, impervious to water, and the general character of the grey chalk is that it is not water-bearing. Above the grey chalk we find that the water increases in quantity as the rock becomes more and more open, until we have a very large body of water in the beds above, and more particularly in the upper chalk. These strata are the sources from which London, and South Eastern England generally, derive the greater portion of the supply of water from wells. You see, then, that we have a very considerable thickness of grey chalk and chalk marl, mostly impervious, to deal with, and below it a layer of gault, in this district not less than 100 ft., while above is the water-bearing chalk.

So much for the general section. I must now examine the position of these strata in the English cliffs. (Prof. Dawkins explained the sections, and continued.) In going from Folkestone to Dover, and from Dover to St. Margaret's, you are gradually passing across the strike of the beds, and you are getting upon newer strata. You will note, too, in this section, that the dip of the beds is exceeding regular and even, and very low, about one in 72 on the average, the lower beds being exposed in the line of cliff between Folkstone and Dover; and the upper between Dover and St. Margaret's Bay, the lower portion of the former being almost impervious, the latter being pervious and abounding in springs which gush out from the base of the cliff between high and low watermarks.

I must now ask your attention to the section I have made

of the French cliffs from St. Pot to Calais. It shows that we have the same series of rocks, in which the grey chalk and chalk marl is nearly of the same thickness. Thus, you see that, both on the French and the English side, the rocks are arranged in the same relative position, and the only difference between them consists in a slightly higher dip on the French side—that dip being about one in 41.

The next point I wish to place before you is the very interesting question as to whether these two sections of the cliffs may be considered to be joined together by a solid mass of rock underlying the Channel. And on that point I would first of all ask your attention to a third section. The Channel itself, I would observe, in its deepest part, where we propose to drive our tunnel, is not more than 210 feet deep; and when we come to consider the history of this "silver streak" we find that there is every reason to suppose that its bottom was in ancient times a valley carved out by streams and rivers, rain, snow and frosts into the same kind of contours as we find to be presented by the chalk downs. The idea, however, is exceedingly common that the severance of this country from the Continent was the result of a great catastrophe by which a huge chasm was developed and the sea let in. This idea is without foundation, and belongs to a bygone age of geological enquiry. No valleys in Britain have been formed in this violent fashion, and, so far as I know, all valleys, excepting in volcanic regions, were formed by forces operating from above downwards, and not by forces operating from below upwards. With regard to the time when this valley was made I should like to say that, in the Pleistocene age, one of the later geological periods, this country was joined to the Continent, and the primeval hunter, whose implements lie scattered through the river gravels in South-Eastern England, followed his game—the reindeer, the mammoth, the bison, and other creatures—over this area

into Britain. At the close of this age Southern Britain was depressed, and the waves rolled over the hunting grounds, not merely in the Channel, but in the estuary of the Thames and Severn. The Channel is, therefore, to be viewed merely as a submerged valley, and in no sense as the result of a chasm or dislocation.

You might say: "This is all very well; you have the coasts on the one side and on the other, but what have you to prove that the strata are perfectly continuous under the water?" I will tell you what I have to say. The French Channel Tunnel Company, as I have already mentioned, have expended a large sum of money and spared no pains in obtaining information about these rocks at the bottom of the Channel. They have had no fewer than 7,672 soundings made for this special work along the narrow strip which extends between Folkstone and St. Margaret's on the one hand, and Sangatte and Calais on the other; and along with these soundings they have collected 3,253 samples of the sea bottom. When we add to this the series of observations which has been collected by our Admiralty, we have a mass of information as to the constitution of the bottom of the Channel, such as we have of no other sea bottom in the world of equal depth. This information is embodied in the geological map of the Channel upon the wall. The upper boundary of the gault is perfectly well defined, and runs across from the French to the English side. The subdivisions of the chalk are not, in my opinion, defined with the same amount of certainty as the gault, because tubes let down to the sea bottom, with heavy weights attached, must bring up more valuable evidence regarding the soft gault clay than regarding the sub-divisions of the harder chalk. Nevertheless, when we know that the beds on the English side and those on the French side, so far as relates to the grey chalk and chalk marl, are as nearly as possible of the same thickness (for they are

so near that on the English side we have 225 feet, and on the French side 223·25 feet for the same strata) it is only reasonable to suppose that they are perfectly continuous across.

The next question to be considered is as to the existence of faults in the sea-bed. The sections in the cliffs prove that faults traverse the chalk; but they are small and comparatively insignificant. The largest I have seen in the cliffs, up to the present time, has not a greater throw than 25 feet; consequently, so far as this evidence goes, we are in a position to say that there is every reason to believe these strata are continuous, without any break of sufficient magnitude to interfere with engineering operations from the English to the French sides. I have represented upon this section all the information that I am able to get regarding the line of the projected tunnel. This section shows: first, the comparative shallowness of the Channel as compared with the great thickness of the rock below; secondly, the continuity of the rock from one side to the other—the cliffs of Folkestone and Dover being continuous with those of St. Pot and Sangatte. The cliff sections also show that these beds of rock are inclined at a very gentle angle on the English and French sides.

It has been objected that Providence has made this country an island, and that it is exceedingly wrong for any one to interfere with that which Providence has ordained. That argument has been met by saying that Providence has placed the lower chalk in a most admirable position for being satisfactorily bored, and given us plenty of it. Providence has also placed it at a gentle angle, which would suit the gradients of the engineers. Therefore, if we may use the Providence argument against, we may also use it in favour of the proposed tunnel.

So much, then, as regards the geological aspects of the

question. There is not, in my opinion, the slightest reason, geologically, why failure should be anticipated; but when I make that remark I would wish to limit it to one of the two rival schemes, namely, that advocated by Sir Edward Watkin—a scheme which starts in the chalk marl and grey chalk at a point indicated in the section, and continues in those deposits under the channel. Looking at the French side, you will see that the French engineers have chosen the same point in the chalk for making their half of the tunnel. The great advantage of choosing such a place is, as already stated, that the rocks are for the most part dry. The rival scheme, that which is advocated by Sir John Hawkshaw, is one which starts very much higher in the chalk. It starts in the water-bearing rocks, and gradually works down through those rocks till it ultimately reaches a point where it is to intersect the tunnel of the French engineers in the grey chalk. The fact of that tunnel being through water-bearing rocks is to my mind fatal to it, for if Sir John Hawkshaw succeeds in beating the springs on the land, and removing the fresh water by pumping, he will probably draw upon the sea when he gets under the Channel. In evidence of that I would mention that in the boring made at St. Margaret's he hit upon a fissure full of salt water, more than 200 ft. below high watermark, in the chalk,—a fissure 3 ft. deep. I would like to ask any engineer in this room if he thought he could carry out satisfactorily a tunnel in rocks which allowed water from the sea to arrive at such a great depth freely? It seems to me that if a tunnel is to be carried to a satisfactory conclusion, it must be not in the porous water-bearing parts of the chalk, but in those which are for the most part impervious. So much then for the geological aspect of these rival schemes. We see that whilst one is capable of being carried out, because

it is mainly in the dry, the other will probably be financially if not physically impossible on account of the water, fresh and marine.

The works now being carried on as a part of the tunnel scheme by the Submarine Continental Railway Company, are as follows :—One shaft has been sunk in the neighbourhood of Folkestone, at the Abbot's Cliff; another at the eastern end of the Shakespeare tunnel, and a third at the western end of the same tunnel. The second of these is 164 ft. deep, and is carried down to the bottom of the chalk marl number 2. When you reach the bottom you find yourself in a tunnel 7 ft. in diameter, lighted by electricity, and at the end of it you see a machine which is driven by compressed air. This compressed air, as it does its work, ventilates and cools the tunnel. The ventilation is perfect and completely under control. I have been there when there has been quite a crowd of people, but in spite of that, the air has been perfectly pleasant and pure, and at a temperature of 52°. The machine cuts 7 ft. in diameter, the cutting portion being composed of two great arms with steel teeth; and the rate at which it cuts is at the present time 100 yards per week. The motive power being compressed air in 4-inch pipes, is far too small for the work it has to do. When 12-inch pipes are laid down it is probable the work will be double that rate,—that is, probably 200 yards per week. The material comes out in small pieces; it is collected in buckets, which deliver their contents into trucks, and the trucks are conveyed out on to the spoil-bank.

The shaft to the east of Shakespear Tunnel is intended for the ventilation and drainage of the tunnel, and without it the tunnel would be useless, and the works connected with it are directly under the guns of Dover. We have read a

great deal during the last three or four months, from military men and others whose opinions are worthy of the highest consideration, about the military aspect of a Channel Tunnel, and the opinions expressed have not been all upon one side. Some major-generals and others, despair of their country, and think that, if we have a tunnel, the foreigner will take it and invade our country; others think this unlikely, and believe that a tunnel is not an avenue of attack. I would point out the fact that while we have command of the sea—even if the major-generals cannot look after the mouth of this tunnel—the admirals and sea-captains can. The works are within easy command of any gunboat in the neighbourhood, which could render it impossible for any invader to use that tunnel at all, whether he had possession of Dover or not. Of course, if we were to lose our command of the sea, the invader could choose his time and place for attacking us. The question of tunnel or no tunnel under those circumstances would be a comparatively small one for us to consider.

Thus you see that, so far as we can ascertain, there is no physical barrier of importance presented to us by nature against this great undertaking. The only obstacle that I see —speaking for myself—is to be found in our prejudices; and I think that our grand-children, if not our nearer descendants, will have occasion to look back to these times with feelings of great wonder. They will wonder how it was that the people who preceded them were so full of fear. They will not have occasion, let us hope,—as some of the prophets seem to think they will,—to lament over the the foreigner taking possession of London, or to moralise over the destruction of the tunnel by the courage of a solitary engine-driver, who apparently was the only man left in that part of England to do a manly act. They will, in my opinion, wonder at our prejudices and our fears, which throw such

extraordinary sentimental objections in the way of this enterprise—an enterprise which, it seems to me, is consistent with all our past history—consistent with all those undertakings which have made this country what it is. This country did not become great through fear. Even if we wished it, we could not shut ourselves off from the rest of the world. To give ourselves to a policy of isolation would, in my opinion, be to go back in the scale of civilization. I, for my part, will not believe that Englishmen of this generation will do anything of the sort.

The following communication on the subject was received from Mr. C. E. De Rance, F.G.S. :—

"I heard Professor Boyd Dawkins' observations on Sir Edward Watkin's address to the Society of Arts, and should be glad to repeat to your Society the remarks I made at the adjourned discussion, on the Channel Tunnel, on Monday last..

"The Upper Greensand in East Kent is practically absent, and the lower beds of the chalk, there locally called the *Grey Chalk*, form with the Gault clay beneath, an impermeable barrier of nearly 400 feet in thickness between the water bearing porous Upper Chalk above, and the porous beds of Lower Greensand beneath.

"The grey chalk of Kent is the Geological equivalent of the chalk marl of Sussex, and not composed of pure chalk, but like other marls has a certain admixture of clay, which gives to it its impermeable character. It is due to its presence that it is possible to work the valuable coalseams of the Belgian and French coalfields, the water bearing white chalk above being entirely separated from the workings beneath, by this impermeable barrier, and it requires no

stretch of imagination to see that it will perform the same office for the Channel Tunnel.

"The white chalk above the grey, is the formation which yields to so many towns an abundant water supply, and to that portion of London supplied by the Kent Water Company, no less than ten million gallons a day from a very limited area. The water in the white chalk, like all other waters on the surface and underground, is derived directly from the percolation of rainfall, the amount annually absorbed varying from 6 to 10 inches. The chalk and other porous rocks around our coasts are charged with fresh water derived from the percolation of rain on the exposed outcrop of these formations on the land, and so long as these rocks are so charged no percolation from the sea itself can take place, but the moment artificial conditions are introduced by pumping, and the water-line is lowered, percolation from the sea at once commences.

"In the northern of the two tunnel schemes now before the public, it is proposed to work in the white chalk, entering it on the north side of Dover, the pumping necessary to carry on the work here must inevitably so lower the water line in the chalk beneath high-water mark as to set up percolation from the sea, and to entirely destroy the existing waterworks supplying the town and garrison of Dover. The quantity of water to be drained will be not less than the absorption of two square miles on either side of the headland, or nearly two million gallons for each mile of tunnel driven or twenty millions to be lifted at each end of the tunnel daily. The Southern Tunnel Scheme commences in the Grey Chalk, and it is intended to keep on this impermeable material all the way, so that the danger of water is avoided, and the consequent cost of pumping."

The CHAIRMAN said he did not gather from Professor

Dawkins what was the length of the proposed tunnel. He also wished to know whether there was any risk of gravel pipes being met with, such as were seen penetrating the chalk in the cuttings. Those were both important points, and another matter of importance was as to the proposition made for the drainage of the tunnel, as sometimes in a tunnel of that kind large volumes of water were met with, and required to be promptly stopped out. The length of the tunnel was important, inasmuch as the ventilation would have to be considered. He did not, at present, know of any air current so long as this was likely to be. In the information he had supplied for Sir Edward Watkin the longest air way mentioned, as occurring in his mining district, was a little over eight miles. That was the circuit which the air had to make. The Channel Tunnel would be probably three times that length. Of course it might be a much larger sectional area, and thereby would facilitate the transmission of air through it much more readily than through some of the more confined passages of mines. The provision with regard to water would be very important, especially as there might or might not be a chance of those gravel pipes being met with from above.

Mr. Stirrup observed that it would be a matter of some surprise if the rocks below the Channel were found to be so "providentially" arranged as the Engineers evidently anticipated, and as were displayed on Prof. Dawkins' section. Among the French Professors there was one, Prof. Hébert, who was lately, if not now, president of the Geological Society of Paris, who had grave doubts about the practicability of tunnelling the Channel. He read, some time ago, before the British Association, papers on the chalk rocks of France, but M. Hébert was not an Engineer, and did not enter into the merits of the tunnel scheme. He had given

his opinion to the public as to the bed of rocks beneath the Channel, and in his opinion it would be perfectly impossible for a tunnel to be driven under the Channel in a straight line or in a horizontal direction. He (Mr. Stirrup), was inclined to agree with Prof. Hébert, who was of opinion that an anticlinal axis would be found running across the Channel. The chalk rocks in the interior of France were thrown into folds; and, judging from the lie of the rocks on the English coast, the same gentleman was of opinion that they would find a fold also beneath the Channel. If the chalk marl,—in which alone, according to Prof. Dawkins, tunnelling was practicable,—were to be tunnelled he presumed they would find varying gradients and that it was also possible the line would not be a direct one. The Chairman had asked Prof. Dawkins a question as to the length of the projected tunnel. He (Mr. Stirrup) did not know what the Engineers might have in their minds,—whether the scheme corresponded with the diagrams now exhibited,—but he would like to ask Prof. Dawkins whether it was usual in Kent, or any of the other chalk countries, to meet with a section of that length without faults, or without those undulations which would greatly interfere with the work of the tunnel.

Mr. W. Watts said he thought that no fear need be entertained as to the practicability of driving a tunnel straight, with the aid of good scientific instruments; and he spoke from having had some experience in matters of this kind. They need not fear the existence of gravel and sand pipes from the bed of the sea, because everyone knew, who had to deal with the filtration of water, that water was a long time in passing through even porous sand, and if a cone several hundred feet in vertical depth existed from the bed of the sea to the tunnel he believed very little, if any,

water would come through; and in any case there would be no difficulty in stopping it, by forcing iron casings in advance of the open heading.

Mr. MARTIN referred to the Westphalian coal field, which he said—as those present were aware—was covered unconformably with the chalk measures. In sinking shafts there, water-bearing strata are generally met with to a depth of about 30 to 50 yards from the surface, whilst below that, frequently for great distances, the strata are perfectly dry. In some places no further water is met with down to the coal measures, but in other cases one of the green sands yields a large body of water. In working some of the collieries it is found that the water increases in the workings only slightly, while in others—in comparatively small areas—large feeders of water break through, but whether through fissures he is not prepared to say. At one of the Mines there with which he was connected they had 120 or 130 yards of dry strata in the shaft above the coal measures; but on driving the levels out a fault was met with and water liberated. Some of the collieries, four or five miles Eastwards, had been drowned out under similar circumstances, the feeders being upwards of 500 gallons per minute, while adjoining ones are comparatively dry. He would like to learn from Professor Dawkins whether the second green sand, or chalk marl, as designated on the section exhibited, was water bearing, or whether the shaft lay between the two beds of water-bearing strata.

Professor DAWKINS said the lower green sand is not represented there at all; it is below the gault.

Mr. PILKINGTON said there was great difference between a colliery and a tunnel. In the former case the water did not break in until they began to get the coal. It came, of course, through the chalk.

Mr. MARTIN, in reply to a member, said that in the mine to which he had referred the water-feeders were met with when the levels only were driven, and they were at a depth of about 200 yards below the water-bearing strata met with in the shaft.

Professor SHALER, of Harvard University, Cambridge, Mass., being called upon, said: I have known something of tunnelling experiments in America—one of them, and perhaps the most worthy, being the Hoosack tunnel. That tunnel cost the State of Massachusetts 2,600,000 dollars; I think it might have been built for one-third of the money if as careful a study had been made of the rocks as has been made in the case of this Channel Tunnel. In the Hoosack tunnel they struck water-bearing rock, when by going half a mile further they might have had very easy ground to work in. I have seen the shores on either side of the English Channel; I have seen something of the faults; and it does not seem to me that the objections which have been raised on account of the folds or faults, are likely to be found a considerable objection in opening the tunnel. The faults to be found there will be compression faults; they will not be like that rarer kind of fault which you get in an anticlinal, but faults which will be pressed together; and anyone who takes two pieces of clay will see the sort of contrast that will be made between the walls of such faults. I do not think that the faults will be more open to water than the other portions of the section. I have seen in Italy some clay beds that mostly resemble these clays—Pleiocene clays—resembling in many respects the grey chalk specimens before us. The beds in Italy, of the newer Pleiocene, in the neighbourhood of Sienna, are folded in an extraordinary way, yet I think all the faults there are as impervious to water as the beds of clay themselves; so it seems to me that breaks of that sort in the Channel district are not likely to present any con-

siderable obstacles to tunnel work. We have, in America, only one specimen of a tunnel bored in similar material to this—that is the tunnel under Boston Harbour, about 2½ miles long, made for sewage purposes, which runs through the boulder clay—a dense clay which was found to be impervious to water, although the sheet of clay between the boring of the tunnel and the surface was not more than 25 feet or 30 feet thick.

As to that question which is now occupying so much attention here—the question of safety, in case a tunnel was built—it is not proper for me to offer any opinion. The greatest successes of our race, it seems to me, have not been made by acting under fears such as those which seem to beset this project in the minds of some persons. My opinion is that our greatest successes have been made by taking much greater risks than those involved in the making of this tunnel.

Professor Dawkins, in his reply, closing the discussion, said: The omission on my part to state the length of the tunnel was quite unintentional. The length is about 24 miles. With regard to the existence of the gravel pipes I do not know any case of gravel pipes occurring in the grey chalk excepting near the surface of the ground. The apex of the tunnel will be in the centre of the Channel, and from it the drainage will find its way by gravitation to the pumping stations on either side of the Channel. With regard to the further question which Mr. Stirrup has raised with regard to M. Hébert, I think I am right in saying that M. Hébert's remarks are of a date preceding the making of that geological map, and that there is nothing to interfere with such a clear section as is here presented. With regard to the suggestion that the section may be a fancy sketch, I can only say that the materials for making

it are ample, and that I have used all the information on the question which I could get. It is plotted on a larger scale than is usual in geological diagrams, and I am, therefore, not surprised that the gentleness of the curves should look doubtful to an eye accustomed to the exaggerated curves of sections in geological works.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVII. VOL. XVI. SESSION 1881-82.

At the ORDINARY MEETING of the Members of the Society, held on Tuesday, the 6th day of June, in the Literary and Philosophical Society's Rooms, George Street, Manchester;

JOHN AITKEN, Esq., Vice-President,
in the Chair.

NEW MEMBER.

ROBERT T. BURNETT, F.G.S., Stanley Avenue, Eccles, was proposed, balloted for, and duly elected an ordinary member of the Society.

THE OWENS COLLEGE MUSEUM.

The CHAIRMAN said: We have had under consideration for some time past the desirability of the arrangement which was entered into some years ago between the authorities of Owens College and the Natural History and Geological Societies, when the transfer of the collections of those Societies to the College was made, being completed. The

Committee of this Society have on various occasions called the attention of the Council of Owens College to this subject, and have urged upon them the necessity of something being done, and various interviews and communications have taken place. A month ago your Council again took the matter up, and a communication was sent to the Council of the College, when an interview was arranged. The result of that interview is embodied in a Report, which will now be read.

Mr. Martin read the report of an interview which had lately taken place between a committee appointed by the council and a number of gentlemen representing the council of Owens College relative to the museum arrangements. The Owens College deputation admitted that the present museum arrangements are not in accordance with the agreement entered into at the time this Society presented its collection, but maintained that the subject has not been overlooked, and that it has frequently been considered by the authorities of the Owens College. They produced plans by Mr. Waterhouse, and explained them, and stated that these were the third set they had had submitted for consideration; the others not being satisfactory. These they think suitable, and they are almost definitely decided upon. The plans include, in one building, accommodation for the natural history, mineralogical, geological, and other collections, also necessary workrooms and laboratories, &c., &c., required by the College. The estimated cost is about £45,000, of which they say they have been promised or know they can obtain about £20,000 or £25,000, the balance being the difficulty. The committee urged upon the members of the Owens College deputation the absolute necessity for their now taking action with as little delay as possible, the terms of agreement on the subject having been so long disregarded. It was then explained that the Owens

College authorities, not deeming the time favourable, had during the past four or five years relaxed their operations in consequence of the depressed state of trade latterly, and the financial position of many of the important local charitable institutions, but as these institutions have now had their "turn," the claims of the College will be again urged and steps taken with a view of obtaining the funds requisite to carry out the agreement for properly accommodating the several museums. In this movement they trust that the members of this and other local Societies will co-operate, and that operations may be formally commenced this year, and that next year they may be proceeded with vigorously. Your committee have pleasure in being able to report in very favourable terms of the proposed buildings and arrangements as explained to them, and believe that when completed they will prove satisfactory to all concerned, and be a credit to this city, which is at present so sadly deficient in such matters.

The CHAIRMAN: Our hope is that the desire which is now shown by the Council of the Owens College may be carried out. The plans provide for ample accommodation for the collections of both Societies. There seemed at the meeting a determination on the part of the gentlemen representing the College to proceed with the scheme, and very shortly I believe they will make an effort to obtain the requisite funds. With the influence that Owens College can bring to bear I do not despair of seeing the scheme carried out.

ON A SECTION OF COAL MEASURES IN SADDLEWORTH.

By Mr. William Watts, F.G.S.

At the northern boundary of the Township of Saddleworth, the Corporation of Oldham is constructing a reservoir to empound the rain-water which falls on the upper reaches of the picturesque moorland valley, Readycon Dean.

In constructing the Readycon Dean embankment, several interesting geological sections have been opened out.

Peat at the surface with the usual valley alluvium is predominant.

Beneath the surface debris, brown arenaceous shales extend over a considerable part of the district, bestowing a rounded appearance to the valleys whether on looking up or down them.

The geological section in which the concrete core for the embankment is placed is fairly divided between shale and rock.

Both of these measures are much disturbed from their normal position near the surface, but at a depth of 30 to 40 feet, they assume a tolerably uniform dip with the valley and are impervious to water.

Valuable pockets of dark blue tenaceous clay have been met with in sufficient quantity for the embankment.

Clay beds averaging from 4 to 9 feet, in thickness, are rarely found in valleys so high above the sea level, hence their rareness makes them all the more valuable.

Undoubtedly they represent the tear and wear of the shaley material previously alluded to, and to some extent indicate an earlier configuration of the valley, as it is impossible to have clay deposits except in still water.

Broken trunks and detached rootlets of trees are occa-

sionally found in the clay which is somewhat silty and stony at the bottom.

The bed is continuous on each side of the valley, and it must have been deposited before the small mountain stream, which drains 270 acres of wild moorland at the source of the river Tame, formed its present course.

The shales yield very few fossils. I have, however, found two small nodules, inside of which *Goniatites*, common in the Yoredales, exist; and in the brook course weathered specimens of *avicula-pectens* are found; but the *avicula-pectens* may have been derived from the shales once existing on higher levels, on exposure to atmospheric agencies.

Nothing else specially interesting to the geologist has yet been found in these shales.

The texture of the rock of the district reminds me very much of the "quartz rock" described by Elias Hall as existing in Staley Wood; Roe Cross, Mottram; and at Bugsworth, in Derbyshire.

With reference to these deposits there may be differences of opinion, owing to the difficulty of defining their true geological position in the stratified series to which they belong.

The continuity is somewhat difficult to trace, so much so that I have been unable, with any degree of certainty, to follow them for any great distance, and I confess that I am unable to say to what place in the Millstone Grit series they should be assigned—if indeed they do belong to the Millstone Grits—as Professor Hull states.

About 500 yards lower down the valley, large blocks of coarse Millstone grit are found, some of which are rounded by meteorological and other agencies; but whether these blocks belong to the Rough Rock or to the Kinder Scout grit I cannot say.

Evidently they are remnants weathered out of parent beds

once existing on the higher extremities of the surrounding hills, which have fallen back on the demands of time and atmospheric agencies.

The most interesting figure on the section is a coal bed 8 inches thick, inclining to the north-west at an angle of 1 in 16. This section is shown on the diagram which is drawn to scale.

It is unusual to find coal so high above the sea level and, as its presence is not indicated on any geological map, or alluded to in Hull's Geological Memoirs, I consider the subject of sufficient importance to lay before this Society.

The section (taken near the outcrop of the measures, and before the inroad was made into the valley with our works,) was hid from view by a peaty covering 18 inches in thickness, and was much disintegrated, but it became more compact farther from the surface.

The coal is accompanied by the usual seat-earth which contains stigmarian rootlets and, if I mistake not, other fossils, but too indistinct for identification.

The section is found on each side of the valley, and in seeking for a continuation of the bed, I find that it harmonises mostly with Hull's description of the coal seam existing under Pule Hill, but as all these thin coal seams are so near alike it is not difficult to mistake them.

Broken as all the strata are on the Penine Range, it requires an experienced eye to find the four Millstone Grit series alluded to by Hull, and except the fossils produced will assist in defining the true geological horizon of this coal bed, I am afraid the rocks and shales will fail in that determination

To me the whole seems very much like the Yoredales, but when an authority like Professor Hull marks them differently, I yield to his opinion.

I have taken four geological sections in the valley in deep

trenches for reservoir embankments, and at some future date hope to be permitted to bring them before this Society, but primarily I wish to identify their exact geological position.

The CHAIRMAN said: I think it is a pity, and detracts very much from the value of Mr. Watts's paper, that he has not made out the exact position of this section. In a district like Saddleworth, which has been gone over by the Geological Survey, and has received the attention of local geologists, one would have imagined that some datum line would have been fixed, whereby the position of the bed of coal might have been determined. From the description of it I should have no hesitation in saying that it belongs to the Yoredale series. The Saddleworth valley, in the lower district, is nearly all of that age; but the higher portions are of millstone grit, the fourth grit coming on round the whole of the hill tops,—forming the "Pots and Pans" and other prominent features in this locality, over a very considerable area. Taking the position of this fourth grit (the Kinder Scout grit), which is found at most places in that district, it strikes me that the position of the coal might have been traced out and its true position discovered. However, Mr. Watts is a gentleman who has had considerable experience in that district; he has paid much attention to it, and as he has failed to discover its horizon, any opinion I might offer would not be considered of equal value with his. The *Goniatites* and *aviculo-pectens*, now exhibited, are characteristic of the Yoredale range, and I think everything points in that direction. There are thin coals, not only in the Yoredale series of this district, but in some parts of Westmorland, where a considerable number of seams exist in this formation, some of which are workable and have a commercial value.

Mr. WATTS said he was much obliged to the Chairman for the expression of opinion which he had given with regard to the position of the coal bed in question. He (Mr. Watts) had been rather too modest in preparing his paper, otherwise he thought he should have expressed his belief that the strata belonged, as the Chairman said, to the Yoredale series; but, inasmuch as it was by Professor Hull referred to as the millstone grit, he was afraid of making a mistake by giving expression to the view which he held.

Mr. Aitken then left the chair, and it was taken by Mr. G. C. Greenwell, Junr.

SAFETY LAMPS
AND THE SAFE LIGHTING OF COLLIERIES.

Discussion on Mr. Teale's paper on "The Safe Lighting of Collieries."

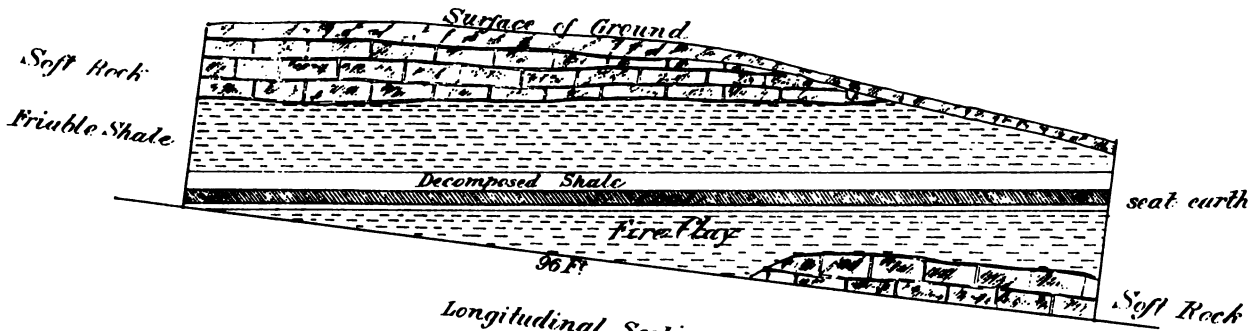
Mr. JOHN UNSWORTH: I consider the Protector lamp to be one of the best lamps as yet proved for the miner as regards the light it gives; the collier cannot open it without detection; but it has the same defect as the Mueseler of going out when handled roughly. The experiments I have conducted leads me to hold favourable opinions of the Williamson lamp. It is safe; it has stood every test to which the Mueseler or the Protector has been subjected; and it gives as good, or a better light than the Mueseler; while it is not so liable to go out, and is not more costly.

Mr. J. S. BURROWS said he would like to hear some discussion on the subject of oils—as to whether vegetable or mineral is best for safety lamps. His experience of mineral oils was that there was in most of them a certain blue cast, which, in testing for gas, gave the impression that gas was present long before it really was so.

Readycon Dean, Valley:

Geological Section showing Coal

Seam 1228 feet above Ordnance Datum



Longitudinal Section

Mr. UNSWORTH said with the oil Mr. Teale used—Colzaline—at 70 or 80 degrees the flame began to get longer, and the collier might be deceived by this and fancy that gas was present when it was not.

Mr. JAMES ASHWORTH said * Mr. Teale's argument (page 308) is not borne out by the experiments made by Mr. Smethurst and myself at Brynn on the Clanny lamp, and as a matter of fact the "combustion chamber" does not influence the passage of the flame through the higher part of the gauze; instances occurred where the Clanny failed in a much shorter time than the Davy.

Cause of failure of the Mueseler lamp (page 310). I differ with the conclusions arrived at altogether. The Belgian Commissioners reported most distinctly that the part of the chimney below the horizontal gauze was more dangerous when very short or very long than when the length was equal to half the distance between the horizontal gauze and the top of the wick tube.

The failure of this type of lamp I attribute to two causes mainly, viz.: Excessive area for the top of the chimney and a want of proper proportion between the cubic contents of the chimney and the cubic contents of the combustion chamber. Because, if the area of the top of the chimney is too large, the contents of the chimney will not be carbonic acid (CO_2), but only a mixture of carbonic acid and carbonic oxide, and some proportion of the ventilating current which has not been in contact with the flame, and this mixture is always most likely to occur in lamps which have the part of the chimney below the horizontal gauze too short and not *bell-mouthed;* and again, if sufficient CO_2 is not present in the chimney to fall down into, and completely fill the combustion chamber, the explosive atmosphere in which the lamp is placed follows the CO_2 down the

* Communicated by Mr. MARTIN, Hon. Sec.

chimney and ignites at the gas which, as a general rule, continues burning under the horizontal gauze after the wick flame is extinguished, and then instantly flashing back explodes the contents of the gauze cylinder, and fires the outer atmosphere after offering a resistance only equal to that of a Davy with a 2¼ inch diameter gauze.

(I note that the proportion of the top of the standard Mueseler chimney to the bell-mouthed base is as 1 to 3, whereas, if my memory serves me, Mr. Teale only gives 4 to 9.)

To sum up these remarks I say, provide sufficient CO_2 to extinguish all fire, and reduce the combustion chamber of the lamp to the most limited cubic contents compatible with the efficiency of the lamp, to produce a safe lamp.

With regard to Mr. Teale's improved lamp, I should like to know why he adopts an ½ inch diameter outlet for his chimney, when the Belgian Commissioners' Report, from which he quotes, sets this diameter down as unsafe; also, how he cleans the "non-combustible substances of irregular shape," and what extra time the cleaning and refilling occupy.

Discussion on "The Tin-Can Safety Lamp" recently shown by Mr. HALL.

Mr. JOHN UNSWORTH: Having made some few experiments myself with the view of ascertaining which was the the best lamp, I think I can very properly give you the result of my experience. I heard Mr. Hall bring before the Wigan meeting the merits of the Tin-Can lamp; and I think, myself, that the principle of that lamp is the right and safe one; and it certainly occurred to me, on examining it, and putting it to the test, that the holes at the bottom might advantageously be dispensed with, inasmuch as there is sufficient room to feed it with air around the bottom or

through the top. But there are other difficulties in connection with the Tin-Can lamp—in working with it—and in order to find out what those difficulties were—because my object in looking into this question of lamps was to find out that which was best to be worked with—not only the safest, but that which the collier could use with advantage—I found that the Tin-Can lamp, when carried in a very strong current of air—in a main air-way for example—was a most useful lamp, inasmuch as whatever current you have, no matter how strong, it was quite effectual in giving and maintaining a good light. But it is well known that at a working face, particularly where you are cutting strait work, you cannot have a strong current of air, consequently where you get the Tin-Can lamp at a strait working face where it is to all intents and purposes out of the air-way, you will find that it burns sleepily and doggedly, and not only so, but it gets so hot in a few minutes that you cannot touch it. That, to my mind, is a great objection, because it unfits the lamp for being used by the workman under all circumstances; consequently if the Tin-Can lamp, or indeed any lamp, is to be adopted it must be one which will answer all purposes of a colliery, particularly when the the collier is at the working face.

Mr. Grimke: With regard to the Tin-Can lamp I never did believe much in it, and do not think now if that lamp was exposed to a high current it would stand, particularly if the current was directed either to the bottom or top of the lamp. I believe if the lamp was put simply in the place where the current could act equally all over its surface it might be safe, but if the current was to act either at the top, so as to force down the gas upon the lamp—or at the bottom, so as to enter by the small holes in the tin, the lamp would explode, particularly so, if these holes are not kept low down.

Mr. WINSTANLEY: I was shown by Mr. William Armstrong a Tin-Can lamp without any holes at all in the tin; but sufficient space was left at the bottom of the lamp for the access of air. The men liked them very well, and considered them a success. They had never fired, although they had been put to a severe test.

A NEW LAMP

Mr. CUNLIFFE, of the Bridgewater Collieries, showed a lamp for which he claimed safety with other advantages:—

In introducing this lamp, I do not think it necessary to occupy your time with the details of the numerous lamps now in use, as I am persuaded that all present are fully acquainted with the subject. I shall, therefore, confine myself to the practical use of the lamp, and the probable objections that may be raised against it.

I will first describe it, viz.:—

The lamp bottom is like the ordinary Davy, or Clanny.

The top consists of bottom brass, five pillars, and top brass with a cone-like finish.

This cone-like top is perforated on the top and down one side only, and has a small shield inside, which covers the holes at a little distance from them, so as to allow a sufficient discharge, but prevent a current blowing through it.

From the top to the bottom brass (inside of the five pillars) is a circular glass, (which may be either in one or two lengths) with an opening in one side from top to bottom. Each side of the opening is fitted with a tin frame, which clips the glass, then, one piece of gauze fills up the opening and is doubled behind each of the tin frames.

This gauze acts as a spring for the unequal expansion and contraction, and supplies the flame with fresh air. The opening in the glass is then covered by a shield, which

extends from one pillar of the lamp to another. The space between the pillars and the glass is very small and is increased towards the middle of the shield, so as to allow a large area opposite the opening in the glass.

This large area, is for two purposes: first, to break any current which might blow through the small space between the pillars and the glass; secondly, to contain a large amount of fresh air so that it may get a little heated before being admitted to the flame. It also causes the lamp, not to be suddenly extinguished when trying for gas, *(where there is no current)*, but as the lamp is unable to discharge sufficient carbonic acid gas, it will not live in an explosive mixture longer than is necessary for examining purposes.

In a strong current, it will not live so long as in a still atmosphere, because the current cannot blow through the lamp, and it therefore checks the discharge in passing over the outlet.

It is with difficulty that it can be kept alive, *even in a pure atmosphere*, where the current is very strong and baffling, (or blowing in several directions) not because the current will blow the lamp out, but because it prevents its discharge.

It will be seen on examination that it is fed with fresh air, much in the same way as the Davy Lamp; it therefore follows that in a still atmosphere or a feeble current it is quite as applicable to all as well as the Davy. In testing for gas, or examining the roof for pot holes, &c., it is not easily extinguished; and as the flame is shielded from draughts or dust, a workman need scarcely ever be without light. Such a lamp would, I think, seldom get tampered with, and would be much saving of time.

In a strong current it will be found to differ greatly from the Davy Lamp (but to prove its safety a thorough test will be required). So far as I have been able to ascertain, a strong current of air seems to decrease, rather than

increase its discharge, of the results of combustion, on account of the top being the only place exposed, at whatever angle it may be with the current; if so, the greater the current the greater will be the safety of the lamp.

The probable objections against it will be the size of the glass, which, after careful consideration, will not look so great as at first sight. It will be seen that the glass has a piece taken out from top to bottom and filled up by a gauze, which acts as a spring for the unequal expansion and contraction, and therefore prevents breakage from that source; and as it is impossible to make a lamp which cannot be broken by a blow from a pick or a piece of coal flying out of the face, and sometimes a fall of coal or roof, I think it is better to look in another direction, viz., to increase the light, so that a collier would be able to see with his lamp at a safe distance from him; and in so doing would not only protect the lamp, but also him from many accidents.

The lamp which I exhibit might be hung at a considerable distance, and would give the collier a good light both at the roof and face, and would require little or no moving about during his work.

For a lock, I should prefer either the leaden rivet or soldering.

AN IMPROVED MUESELER SAFETY LAMP.

By Mr. James Ashworth, M.E., Derby.

(Communicated by Mr. Martin, Hon. Sec.)

The papers and discussions on the various forms of safety lamps clearly show that the members of this Society, unlike those of several kindred Societies, still take an unabated interest in the subject, and are not willing to waive all questions of this class until after the Mines Accidents

Commission have published the results of their extended investigations, and with this fact in view I now offer you a few remarks on the Mueseler type of safety lamp.

The Mueseler type of lamp has been said to be in every way superior to the Tin-Can type, and as it is the type of safety lamp approved by the Belgian Safety Lamp Commission, and proved by the experiments made by Mr. Smethurst and myself to be the best type of lamp, for an all round lamp, I shall not be out of place in referring to some of the pertinent remarks made by the above Commission in their report :—

"*Ascending* currents were found eminently dangerous. It was "noticed that each time an explosion took place the position of the "lamp experimented on was such that, before the arrival of the gas "the flame of the wick was found to vacilate strongly or to be crushed "down on the wick, which indicated the presence of whirling currents "or eddies in the moving mixture, whereby a sudden ascending in-"flection was produced in the current just as it began to impinge on "the lamp. Thus the frequency of the explosions was much oftener "caused by these whirlings or eddies than by the simple velocity of "the current, and the whole of the experiments made by the Com-"mission prove that only those circumstances may be considered "dangerous which *reverse* the current of air and cause them to flow "in a *different manner* to that which the lamp was designed to pro-"duce, and the reversal of the current is made manifest by the "agitation and beating down of the flame."

When concluding the paper prepared by Mr. Smethurst and myself, on safety lamps, we intimated that probably we should, on some future occasion, introduce one or more improved safety lamps to your notice, and I now take the opportunity of submitting my improved Mueseler, which is designed specially to secure the weak places noted by the Belgian Commission in their report.

I believe this form of lamp possesses the following advantages :—

1. That it will stand any velocity of air without flickering.

2. That the ventilation of the lamp cannot be reversed.

3. That the flame cannot be crushed down on the wick by whirling currents or eddies.

4. The complete extinction of the wick flame and gas, without the addition of the second horizontal gauze of the Mueseler Joassin, Muesseler Demanet, or Mueseler Godin D., which is recommended to be added by the Belgian Commission to increase the safety of the ordinary Mueseler.

5. A much superior light to the ordinary Mueseler.

6. A stronger form of glass for the combustion chamber.

7. The reduction of the cubic contents of the part of the lamp exposed to the direct action of the exploded or ignited gas.

8. That the chimney contains a larger volume of carbonic acid gas, in proportion to the cubic contents of the glass cylinder, than is found in any other form of this type of lamp.

These advantages arise from two very cheap and light additions to the lamp, viz., a light copper or tin shield above the horizontal gauze, which touches the chimney at six equidistant points and prevents any current passing through the horizontal gauze on one side of the chimney and out again on the other side, as it may do in the ordinary Mueseler; and, also, by an appendage which I term a "chimney pot," consisting of a cylinder containing three wings, which commence a little above the top of the chimney and extend to a little below the bottom of the cylinder, dividing the "pot" into three compartments.

With these additions a continuous and steady current is maintained in the lamp, because the force of the ventilating current cannot act directly on the top of the chimney, nor on the horizontal gauze; and no more air can enter the combustion chamber of the lamp than is required to supply

the wick flame, the air so entering is highly heated by direct contact with the chimney, and arrives at the lamp flame in the most favourable condition to produce a perfect combustion and a superior light.

I have adopted gas oil in preference to vegetable oil because it is cleaner and gives a superior light, and also because in the event of the glass breaking from a blow, the concussion of the air inside the lamp cuts the flame off the top of the wick tube, and no dangerous results can follow, hence two cylindrical or conical glasses are unnecessary.

I have, of course, taken into consideration the adverse report by the Belgian Commissioners on the use of mineral oils (petroleum), in which they say "they thought that by "their nature and the great variation in their composition, "they were too dangerous for their use to be authorized in "firey mines;" but I find no trace of any experiments with gas oil, such as is in daily use in many mines in England, without accident. So far as my own experience goes, I consider it safer than any other oil for the purposes of a safety lamp, and I see no reason to fear any accident when it is used in a properly constructed lamp.

I have tested my Mueseler lamp with a view to the ignition of the gas under the horizontal gauze, but without success. I also put it into the hands of Mr. D. P. Morison to be tested, and he reported that the lamp appeared to stand the test of the gas well up to 19½ feet per second (this being the highest explosive velocity available on this occasion), and lastly I forwarded it to the Mines Accidents Commission.

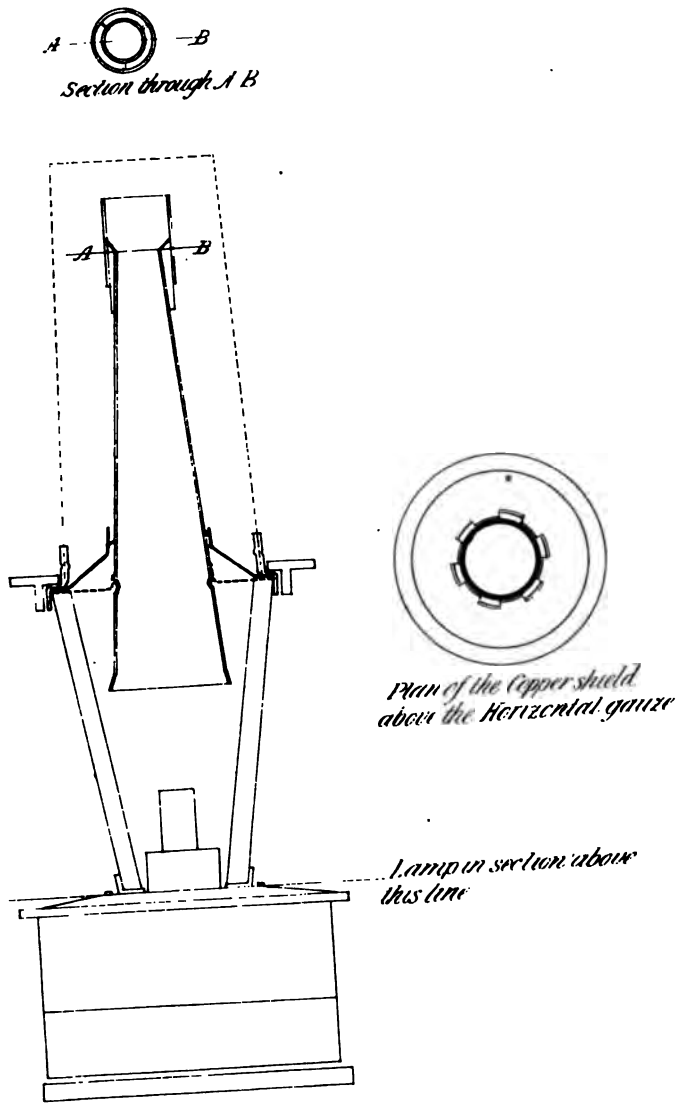
The lamp tested as above had the bell-mouthed end of the chimney made of glass, but as this construction necessitates three loose parts instead of a continuous metal chimney, some of my friends considered that the gain in light was not counterbalanced by the extra trouble in cleaning, and I have therefore omitted it in the present sketch.

We can have no hope of our Government making the use of any particular lamp compulsory (as the Belgians have done), but this Society and all kindred Societies can impress upon it the necessity for the enforcement of lamps of standard types only, and the abandonment of all lamps which are not constructed according to such standard types; also that all new lamps which may be introduced and patented from time to time shall receive the authorization of our Home Office before they can be used in any mine.

Before concluding, I wish to draw the attention of our mining members and lamp makers to the superior finish of the Belgian gauzes with pressed copper rings, which are made to clip the top of the cylindrical glass, thus saving the two loose rings (one inside the cylindrical gauze and one on the top of the glass) of an English made lamp, and also that no part of my lamp is protected by patent rights.

Mr. Grimke: We put the Mueseler lamps into one of our mines, and they proved a failure, as I myself have seen them fire three or four times over. The only question with us was whether the flame of the gas went up the chimney or through the horizontal gauze. At present we are making a lamp by means of which we can cover the top of the chimney with a gauze, and put in two or even three horizontal gauzes; and by that means we hope to ascertain whether the flame passes up the chimney or through the horizontal gauze.

Mr. John Unsworth: The Mueseler lamps, up to a very recent time, or—I might say up to the present time—has been believed to be perfectly safe under all circumstances, but it had its difficulties, and so far as the collier was concerned, in the same way as the Tin-Can lamp. It is not easily moved or carried from place to place. A boy for instance, drawing from a collier at the working face



ASHWORTHS IMPROVED MUESELER LAMP.

will find that he has a great difficulty in keeping a light in his Mueseler lamp, so will officials carrying it in their hands, when passing round the workings. I tried this lamp myself, and using it with the greatest care possible, I, on several occasions, lost my light; and if I, using that care, found myself subject to that disability, the collier, who would probably not use the same care, would be all the more likely also to lose his light if he carried this lamp. In some collieries where the workings are very extensive—extending as they do even thousands of yards from the lamp station—the collier must have a spare lamp, or otherwise he would for one-half of the day be without light. This, to my mind, is a very great objection to the Mueseler lamp at present. The Williamson lamp seems to me to be equally safe, and it has successfully stood such tests as I could subject it to. This lamp is not so liable to go out, while it gives an equally good light with the Mueseler.

Mr. Martin said there could be no doubt that the lamp required was one which would go out when it got into an explosive mixture, because, if the explosive mixture be present, and it continues burning inside the gauze, something or other will ultimately give way and result in an explosion. Lamps should be considered as useful for indicating the presence of gas, and a safeguard in case of a sudden emission, but not for remaining in it. With regard to the Mueseler lamp, Mr. Unsworth's statement about its so readily going out when carried by persons who have not been accustomed to them is quite correct. At the same time, workmen who are accustomed to use the lamp constantly say that it does not give as much trouble in this way as might be expected from one's own experience. Mr. Teale's lamp required even more careful handling than the ordinary Mueseler, which in itself is not an undesirable feature. It is liked in many places where used on a large scale.

Further discussion was adjourned to the next meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART XVIII. VOL. XVI. SESSION 1881-82.

At the ORDINARY MEETING of the Members of the Society, held on Friday, the 30th day of June, in the Council Chamber, Municipal Buildings, Wigan.

GEORGE GILROY, Esq., M.Inst.C.E., President, in the Chair.

CENTRIFUGAL FANS: THEIR RELATIVE EFFICIENCY AND USEFUL EFFECT.

BY CHARLES COCKSON, M.E.

The question, as to which is the most efficient and economical method of mine ventilation, has been so often discussed during the last 20 years, that it might have been thought by this time there would be really nothing fresh to say about it; and that the question would be one with regard to which engineers must have come to almost an unanimous decision. But as a matter of fact, I think we must own that such is very far from being the case; papers still continue to be read on the relative advantages of the different systems—ventilators of different types still continue to be put up, and so late as December of last year, a committee of the North of England Institute of Mining and Mechanical Engineers, which had been appointed some three years before, presented to their Institute a most elaborate

report on the actual work done by 12 different mechanical ventilators; the twelve machines belonging to no less than nine distinct types of ventilators, all of which, with one exception, are now at work in this country. So that I think we may safely say that the question is still undecided, and as I am sure will be admitted is of the greatest importance to all interested in mining matters.

Looking through the proceedings of our Mining Institutes, we find that soon after the introduction of mechanical ventilators, on a large scale, into this country, the question discussed was, as to the advantages or disadvantages of mechanical as compared with furnace ventilation, persons holding very decided views on both the one side and the other—the fear of a sudden stoppage of the ventilation, by reason of some breakdown of the machinery, appearing to make many side with the advocates of furnace ventilation.

Now-a-days, it has become more a question as to which is the best mechanical ventilator, as we see that fan engines and fans should not, and with very rare exceptions, do not break down; and the power of being able to increase, at any time, the volume of air circulating in a mine to an extent that is quite impossible with furnace ventilation, has convinced the majority of engineers, at any rate, that on the ground of safety and efficiency, mechanical is greatly preferable to furnace ventilation; and that at our present usual working depths, it is also the more economical. I do not now mean to say anything as to the work done by furnaces, as nearly all are agreed as to the superiority of mechanical ventilation of one kind or the other.

Taking the report of the North of England Fan Committee as our guide, and before passing on to my analysis of it, I feel that I ought to pay my tribute of admiration to the careful and exact manner in which every detail and result has been noted and recorded in this report; everything seems to have been done with such mathematical accuracy, and the

results have been so well arranged as to form a perfect record of the work of the ventilators reported on. Taking this report as our guide, we find that all the ventilators described in it may be divided into two clearly and radically distinct classes:—the first consisting of the Waddle, Guibal, and Schiele Fans, which are centrifugal ventilators, and act by reason of the partial vacuum they are able to produce; and the second consisting of those machines which are known as varying capacity ventilators, and which act after the manner of an air-pump.

To this latter class I do not mean to devote much of your time, as in my opinion they are not at all suited for the enormous volumes of air which are required for the ventilation of our collieries of the present day. Of this class the committee report on the Lemielle, Cooke, and Roots' ventilators, which are rotary displacement machines; and the Struve, Nixon, and Goffint, which are simply enormous exhausting air-pumps, and my objections to this class apply in a greater or less degree to all these ventilators, and may be briefly stated as follows:—

1st. They are much more complicated machines than centrifugal ventilators.

2nd. Their efficiency is greatly dependant on the most accurate fitting of the working parts of the ventilator; and in the Struve, Nixon, and Goffint, to the good condition of a large number of air valves which, unless they are very well looked after, must seriously interfere with the useful effect of the ventilator.

3rd. At a certain speed they can only pass a certain quantity of air, and in my opinion not one of the machines described could be safely run at a sufficiently great number of revolutions, to pass the quantity of air being turned out by some Guibal fans, of from 250,000 to 300,000 cubic feet per minute.

It would, I think, be a mechanical impossibility to produce

this volume of air by any variable capacity machine yet made. Owing to this, the limit as to the ventilation obtainable is not so much a question of what the conditions of the mine will allow, but at what speed the ventilator can work; so that with this type of ventilator you would not reap the advantage due to large shafts and good airways, as the ventilator to produce a given quantity of air has to run at nearly the same speed whether the roads are in good or bad order.

4th. In case of a breakdown, there is no air-passage through the machine, this necessitating the construction of other outlets which can be opened in case of a stoppage of the ventilator.

What the result of an explosion would be on one of these machines I cannot say, but should fancy it would stand a much greater chance of disablement than a fan, on account of its not affording a clear passage through the ventilator, and on account of the probable disablement of the air-valves, &c., which would, I fear, certainly be put out of order.

5th. The conditions of the mine remaining the same, they do not (as do the best centrifugal fans) produce a certain fixed amount of air per revolution.

As the speed increases, the re-entry or loss of air inseparable from this type of ventilator also increases, so that with big speeds and high-water gauges this re-entry of air will very much detract from the economical working of the machine.

6th. With a centrifugal fan, if a very heavy fall takes place in an air-road, so as to decrease the quantity of air, it will at once lessen the work of the fan, and the fan will work more quickly, thus tending automatically to restore the ventilation to its original volume.

With the varying capacity machines the same fall would increase the Water Gauge, tend to make the machine go more slowly, and increase the re-entry of air, and thus

decrease the volume of air in the mine. But perhaps the most convincing argument as to the superiority of centrifugal ventilators is the simple fact, that while the varying capacity machines at work in this country may, I believe, be counted on one's fingers, of the Guibal Fan alone there are between 250 and 300 at work; and on the Continent, where all types of ventilators have been more fully tried than with us, the centrifugal ventilator is now being put up, practically to the exclusion of all other types.

Let us now turn our attention to the centrifugal fans, and still keeping the North of England report as our guide, let us try and determine which of the three types of fan described (the Guibal, Waddle, and Schiele) are giving the best results.

Taking the useful effect of these fans, as calculated in the usual way, by taking the ratio between the horse power in the air current, and the indicated horse power in the steam cylinder, we find that the fans range themselves as follows:

		Useful Effect.
1.	Guibal, Pemberton	52·95 per cent.
2.	Waddle, Calynan	52·79 „
3.	Schiele, Car House	49·27 „
4.	Guibal, Cannock Wood	47·95 „
5.	Schiele, Corton Wood	46·12 „
6.	Guibal, Hilda	40· „

Looking at these results, I fear we cannot very well say which type of fan is the best, for we have the apparent anomaly that of six fans tested, the Guibals are first, fourth, and sixth on the list of efficiency, a Waddle is second, and the Schiele's third and fifth.

I must say that these results do not convince me of the superiority of either one fan or the other, but appear at first sight rather to bear out the theory of every fan maker, that his own fan is the best; and doubtless with results so varying as these, he may be able to show a fan working with a

very high useful effect; in fact, doing much better than any of the fans reported on by the committee.

These results appear to me to be very contradictory, and made me determine to try and ascertain where the fault lay, as the difference of results appeared either to show some error in the calculation, or some dissimilarity in the testing, as I could not see why the Guibal at Pemberton should give 52·95 per cent., while the Hilda fan, of similar construction, should only give 40 per cent. of useful effect; assuming the testing to be a fair standard of comparison between the two fans.

On looking through the report of the experiments, I noticed that the quantities of air and water gauge produced by the various fans were different in each case, so that I think we may assume that the fans were tested at their usual working speed, and under the ordinary conditions of the mine, which conditions must vary very much at different collieries on account of the size and length of air-ways, shafts, &c.; and taking the two first fans on the list, we find that at Hilda the conditions of the mine will only allow 108,000 feet of air per minute to circulate, with a ventilating pressure of $3\frac{4}{10}$ths inches of water gauge, whereas at Celynen the much greater quantity of 163,000 is being produced with a lesser pressure of 3·08 inches of water gauge, showing that the conditions of the mine at Celynen are much more favourable to producing a large ventilating current than are the conditions at Hilda. Briefly stated, my opinion is, that taking different fans under different conditions is not a fair test of the merits of the fans, as we take into our calculations a varying quantity—namely, the amount of air circulating, which depends solely on the conditions of the mine at the time of testing, and which quantity does not vary in the same ratio as does the horse-power required to produce the extra quantity of air under the altered conditions.

Feeling convinced that the contradictory results of the

testing of the different fans was mainly due to the different conditions of the various mines, I determined practically to try the effect of testing a 30 feet Guibal Fan, under conditions at first favourable to the production of a large current of air, and then under the reverse conditions, so as artificially to alter the conditions of the mine—by increasing or decreasing the friction of the air. This I did by opening the doors a little in the fan drift so as to allow the fan to draw some of its air directly from the atmosphere, and again by building a scale of planks in the return airways underground I was able greatly to increase the friction, and consequently lessen the amount of air circulating; and so that the fan should be able to give the maximum amount of efficiency possible, I had the regulating shutter altered to suit the varying quantities of air. The results obtained were as follows:—

1.—*Doors in fan drift partly open.*

Air per Min.	W. G. Fan Drift.	Useful Effect.
78679	1·20	59·25 per cent.

2.—*Ordinary conditions of Mine.*

Air.	W. G.	Useful Effect.
64800	1·22	56·36 per cent.

3.—*Returns scaled.*

Air.	W. G.	Useful Effect.
34700	1·23	38 per cent.

So that with the same fan working at the same speed, by altering the conditions of the mine, we get a useful effect of 59·25 in one case, and of 38 per cent. in the other. This experiment convinced me that to make a fair comparison as to the useful effect of different fans, we must make the conditions the same—so that when testing them they may produce similar quantities of air under similar water gauges. When this has been done, and not until then, shall we, in

my opinion, have made a fair comparison of the useful effect of the various types of fans.

Since it is impossible with our present experiments to decide this question, let us look at one or two other points which, in my opinion, are almost as important as the question of the per centage of steam utilized; and in order to do so, let us consider what the work of a fan really is. Primarily, of course, its work is to produce a ventilating current in the mine, and in order to do this, it must so decrease the pressure of air in the upcast column as to induce this current, due to the greater pressure of air in the downcast column, acting in accordance with exactly the same laws as furnace ventilation; and as we can calculate the ventilating pressure that a furnace will give when we get certain temperatures of air in the upcast column, so can we calculate what ventilating pressure can be produced by a fan running at a given speed; and since the quantity of air in a mine depends on the ventilating pressure or water guage our fan can produce, the question as to which type of fan is able to produce the greatest water gauge is one of great importance, as this fan will be able, under similar conditions, to produce more air than a fan which is not able to produce so great a water gauge; or, putting it in another way, we may say that the fan which at a certain speed can give the greatest water guage is the most efficient ventilator. In order to arrive at some standard by which to compare the fans as to their efficiency in this respect, let us consider what theoretically a fan should do, and then we can see how they compare with this theoretical perfection.

In all centrifugal fans with radial blades we may consider that the air leaves the fan at the speed at which the tips of the blades are travelling, and theoretically the pressure due to this velocity, as measured by the height of air column required to produce this velocity, is found by the formula $H = \frac{U^2}{2G}$, where

H = height of air column in feet;

U = the velocity at which the air is discharged in feet per minute; and

G = 32·2, representing the force of gravity.

This formula gives us the pressure which can be produced by an open running fan which discharges the air it draws from the mine into the atmosphere at the velocity at which the tips of the fan blades are travelling.

Now air, like all other bodies, whether solid or gaseous, when raised to a given speed has a certain amount of work stored up in it, and this work is nearly all lost by all open running fans, or fans which have not a close fitting casing.

Now, if we can utilize any of this stored up work by lessening the velocity of the air before discharging it into the atmosphere, we shall thus increase our vacuum, and also the useful effect of our fan, and it is to gain this result that the expanding chimney was devised by Monsieur Guibal and added to his fan.

Now, if all this stored up work could be utilized, and the fan caused no friction to the air in passing through it, our formula for the pressure in feet of air column, which a perfect fan could produce, if discharging its air at an impossibly small velocity, would be $H = \frac{U^2}{G}$; and in order to convert H into inches of Water Gauge we must multiply our result by the factor ·00000408.

Having done this, we get a formula by which we can find the Water Gauge which a perfect fan could theoretically produce at any speed; and comparing the fans reported on by the committee, we find that they get the following percentages as compared with our theoretically perfect fan.

	Per Cent.
Guibal at Hilda	64·88
Guibal at Pemberton	57·75
Guibal at Cannock Wood	56·4
Waddle at Celynen	44·88
Schiele at Car House	36·78

From this we see that the Guibals are at the head of the list with regard to their water gauge efficiency; but in order to take a fairer average I have worked out the per centage of efficiency in this respect of some six Guibals, three Waddles, and five Schieles, of whose working I have particulars, and averaging the results I find they give the following comparison of efficiency with regard to W. G. produced:—

Guibals	64·5
Waddles	44·78
Schieles	34·54

Taking these as a fair basis for calculation, we can find out approximately what each of the three types of fans will do at the same or different speeds; and taking 9000 feet per minute of periphery speed as being about the limit of safe working speed of fans of such dimensions as will pass large volumes of air, we find that at this same speed the different fans will give the following results:—

	Water Gauge. Inches.	Air per Min. Cubic Feet.
Guibal	6·61	200,000
Waddle	4·59	166,780
Schiele	3·53	146,160

Showing that if the fans were all working under similar conditions, and at the same speed of periphery, that the Waddle would give 16·6 per cent., and the Schiele 26·9 per cent. less air than the Guibal, or putting it in another form, we find that to produce the same amount of air the Waddle will have to run at 20 per cent., and the Schiele 36·6 per cent. greater speed than the Guibal, so that whatever the result as to the useful effect calculation, we may say that as a matter of efficiency with regard to the speed of the fan, the Guibal is the most efficient.

This test as to the Water Gauge produced is, I think, one of great importance, and will, I trust, be of service to those who may be thinking of changing from furnace to fan

ventilation, since by the averages given we can calculate what size and speed of fan of any of the types named will be required to get either the same quantity or any increased quantity of air that the mine requires, the only data wanted being the amount of air produced by the furnace, and the ventilating pressure at which that quantity is produced, care being taken that the Water Gauge is calculated from the actual temperatures, as the W. G. recorded in the mine does not register the total ventilating pressure.

The practical fixity of the water gauge, as shown in the experiments before detailed, where an increase of 120 per cent. of the volume of air only altered the water gauge three hundredths of an inch, is of course not absolute, a fan being kept at a certain speed is bound to cause more friction to the passage of 200,000 feet of air through it than if only 100,000 were passing; but as a factor for calculating the dimensions and speed of a fan to do certain work, the average may be safely taken and the water gauge regarded as being unalterable within the ordinary conditions of mine working as long as the speed remains constant. The shutter of the Guibal Fan not being properly regulated, is, I think, the main cause of some of the fans of that type giving a less efficiency than others, as I know of Guibals which are passing large volumes of air and giving 70 to 74 per centage of water gauge efficiency, which is considerably above what I have given; so that the average for the Guibals, at any rate, may be safely taken in calculations, it being under the average.

In conclusion, I much regret that I have not been able to lay any more definite conclusions before the Society, but trust that, at least, I may have done some good in the way of opening a subject for discussion and for further papers by other members, which will doubtless contain more information than my own, and will tend to the settlement of the oft debated question as to which is the best mechanical

ventilator. With this object in view I have written this necessarily incomplete, and imperfect paper, and trust that some one more able than myself will now take the matter in hand, and if possible, work it out practically, as results of actual work done are much more satisfactory than theory, and if my paper will in any way lead up to this, I shall feel amply rewarded for any work it has given me.

Mr. C. M. Percy handed as an Appendix the following Table of Results obtained by him from various fans :—

Type of Fan.	Circumferential Velocity in feet per min.	Water Guage in inches.	Cubic Feet of Air per min.
1—Guibal	3468·0	1·125	120,000
2—Guibal	5780·0	2·700	300,000
3—Guibal	3769·0	1·100	76,000
4—Guibal	4520·0	1·500	138,243
5—Guibal	5635·0	2·900	278,000
6—Guibal	5024·0	2·250	126,000
7—Guibal	4470·0	1·750	122,848
8—Guibal	3768·0	1·250	66,187
9—Guibal	3770·0	1·250	63,000
10—Guibal	6069·0	2·600	260,300
11—Guibal	6647·0	3·750	250,000
12—Guibal	4335·0	1·500	191,000
13—Waddle	5652·0	1·750	110,000
14—Waddle	6531·0	2·400	210,000
15—Schiele	6452·0	1·800	147,000
16—Schiele	6050·0	1·500	60,700
17—Schiele	5970·0	1·200	90,000
18—Schiele	5032·0	1·500	160,000
19—Schiele	4077·0	1·600	67,730

Mr. William Bryham said he rather agreed with Mr. Cockson that the time was coming when mechanical fans would be more generally applied than they had been, but thought we had hardly arrived at the time when they could be said to be, under some conditions, altogether superior to furnaces for ventilation purposes. He hoped that the paper would lead to further consideration of this very useful subject.

Mr. Percy said there were some debatable points in the paper, and some to which he should take exception. He was not content to admit that the Guibal fan was so much better than others, as Mr. Cockson seemed to think.

Mr. Cockson said he did not doubt that at certain depths furnace ventilation was found to be more economical than the fan ventilation.

The discussion was adjourned.

THE SAFE LIGHTING OF COLLIERIES.

The discussion on Mr. Teale's paper on this subject was resumed.

Mr. Teale said that Mr. Ashworth was reported to have said that his (Mr. Teale's) argument was not borne out by the experiments made by Mr. Smethurst and himself at Brynn with the Clanny lamp, and that as a matter of fact, the combustion chamber did not influence the passage of the flame through the higher part of the gauze. The statement he made was that a Davy lamp was more easily exploded than a Clanny lamp. If Mr. Ashworth proved the contrary, so much the worse for their experiments. He had shown that the Clanny lamp had a combustion chamber containing carbonic acid gas, and it stood to reason that it must influence the point at which it would explode in comparison with the Davy lamp. It is well known that the more free the lamp was from carbonic acid gas the more liable was it to explode. It had also been said that the Belgian Com-

missioners had in some respects reported adversely concerning the Mueseler lamp, with regard to the shortening of chimney. He (Mr. Teale) had read the report, and it did not seem to him to bear out the interpretation put upon it by Mr. Smethurst. He maintained that experience so far had shown that the Mueseler type of lamp was the safest and best for collieries.

Mr. SEDDON said there was a certain blue gas emitted when mineral oil was used. That was the case in his experience, and if Mr. Teale could see his way to remedy that, his objection would be withdrawn.

Mr. TEALE remarked that the only way to minimise it was to have the lamp tested. The same objection had been mentioned to him several times. One gentleman was so satisfied with the facts of his case that to test the matter they went into a stable, where there was no chance of any explosive gas being about. They tried the lamp there, and most distinctly it showed a blue cap on, but it was only the reflection of the light on the glass when it came to be looked at carefully.

Mr. GRIMKE enquired whether the mineral oil which Mr. Teale recommended was really safe in storage. A fear had been expressed that a barrel of the liquid might accidentally be broken, and by coming in contact with a light, produce an explosion.

Mr. TEALE said there was undoubtedly a risk in the storage of the oil, and the greatest care ought always to be exercised. It was sent out in hermetically sealed vessels, and its inflammable nature was clearly indicated on the outside of the tins. And if the suggestions offered were followed in the trimming and use of the lamp and oil, they were far safer than any other kind. Lamp-room arrangements provided for the oil being kept outside.

In answer to Mr. Bryham, Mr. TEALE said he had repeatedly made experiments to test the amount of evapora-

tion, and found that by properly regulating the flame there was scarcely any.

Mr. H. HALL asked if it was not a fact that the lamps (Mueseler) would go out when officials or others were seeking for gas, and so leave them in the dark.

Mr. TEALE said there was very little doubt that if they plunged their lamps into gas many seconds would not elapse ere the light went out, and no doubt the Davy lamp would enable them to deal with that question more satisfactorily; but those who had used the Mueseler lamp for some time found that it was a very efficient lamp to test with. But when it was a question of turning the lamp on to its side in order to find gas the lamp would go out. It was an advantage in that respect.

Mr. HALL said he had heard it stated that every now and then the lamp gave off a certain amount of vapour, at which the flame of the light caught and set it on fire. He wished to know if Mr. Teale had found it to be so.

Mr. TEALE replied that he had on one or two occasions, but in the particular lamp which he advocated such a thing need not occur.

Mr. S. GILROY expressed his opinion that what was really wanted was a lamp without flame. He thought that one of these days our chemists would be giving them a brilliant light without flame.

Mr. SEDDON said they used nothing but the Mueseler lamp at the mine with which he was connected, and it answered satisfactorily.

Mr. W. PICKARD enquired if Mr. Teale had had a report of a lamp glass cracking and thereby causing an explosion.

Mr. TEALE answered in the negative.

Mr. HILTON gave the results of some experiments he had made with the Mueseler lamp to test its power of withstanding heat. The experiments resulted satisfactorily.

Mr. HALL: Have you had any lamps broken since you put them under ground?

Mr. HILTON: Yes; but none dangerously broken.

The CHAIRMAN: Have any glasses been cracked?

Mr. HILTON: Yes, but not cracked so as to be dangerous, and requiring the men to come out.

Mr. GRIMKE mentioned instances in which he found the flame of the Mueseler lamp coming in contact with a strong current in the roadways passed into the upper gauze and burnt there the same as a Davy lamp.

Mr. BURROWS said they had a thousand of such lamps in use every day, and had not experienced any of the results referred to by Mr. Grimke.

Mr. GRIMKE said the case he alluded to was an ordinary one that might occur in any mine. They were simply carrying the lamp along the travelling road against the air.

Mr. HOLLINGWORTH thought Mr. Grimke's case was a practical illustration of what might occur by baffling the air.

TIN-CAN LAMPS.

Discussion on the Tin-Can lamps shown by Mr. Hall.

Mr. TOPPING bore testimony to the excellent character of the Tin-Can lamps. At his colliery four hundred of them were in daily use, and not the slightest difficulty had been experienced in using them. By allowing a sufficient space between the can and the lamp there was no accumulation of dust.

Mr. BRYHAM spoke in favour of their old friend the Davy lamp. It was as safe as any lamp in ordinary circumstances, but it was the extraordinary circumstances they wished to guard against. At the same time he was rather in favour of the Tin-Can lamp; it might be made a workable lamp, and he believed a safe lamp.

At the close of the meeting a vote of thanks was passed to the Mayor of Wigan for allowing the use of the Council Chamber.

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